RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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RADIOLOGY

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Vol. 73 OCTOBER 1959 No. 4

Observations on the Radiologic Anatomy of the Oesophagogastric Junction[1]

ALAN S. JOHNSTONE, M.D.

A YEAR AGO Atkinson and his colleagues (1) published an account of pressure studies made at the cardia and pylorus and pointed out a paradox in the relation between structure and function. At the cardia, where there is no known anatomical sphincter, they found a physiological one, whereas at the pylorus with its classical anatomical sphincter there was no evidence of physiological function. They came to the conclusion that it is not possible to establish the presence of a sphincter mechanism by radiological methods alone. Such a challenge could not go unanswered, and I am sure that each time a radiologist tries to manipulate barium through a refractory pylorus he will think of that statement and wonder if it is just possible that pressure recordings can lie. At the gastro-oesophageal junction the problem is much more complex, and this paper has been written in an attempt to correlate some radiological observations with pressure studies.

Fig. 1. Smooth ring constriction, indicated by the arrow, at the junction of the oesophagus and the pouch of a hiatus hernia.

Many radiologists must have looked at a film displaying the lower oesophagus flooded with barium as it was regurgitated from the gastric pouch of a hiatus hernia and observed at the junction of the two structures a smooth constriction about 1.0 cm. wide (Fig. 1). Perhaps some would call this narrowing the constrictor cardiae but it is never seen when the stomach lies completely below the diaphragm. I propose to show that the constriction is part of the intrinsic sphincter mechanism of the lower oesophagus because it contracts and expands (Fig. 2), and furthermore that it may correspond to the inferior oesophageal sphincter of Lerche (2). It is always seen in the sliding type

[1] From the Department of Diagnostic Radiology, General Infirmary at Leeds, England. Presented at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16–21, 1958.

Fig. 2. A. Ring constriction during a quiescent phase, indicated by the arrow.
B. Expansibility of the segment during reflux.

Fig. 3. Residue of barium in the oesophagus apparently held up by intrinsic sphincter mechanism.
Fig. 4. Narrowed segment in the lowest 2 cm. of the oesophagus in a case of hiatus hernia, showing intrinsic sphincter mechanism to be independent of the diaphragm.

of hiatus hernia and is often found in the normal patient who has a prominent gastro-oesophageal vestibule but no hernia.

There appears to be no doubt from the many papers on pressure studies—most of which originated in America (3–9)—that there is an internal sphincter mechanism in the lower oesophagus which extends over a segment of varying length, probably 2 to 3 cm. on an average. Somewhere within this segment the pressure waves change suddenly from the abdominal to the thoracic type, indicating a barrier zone which has been estimated to be about 0.5 cm. long. With this conception there is radiological agreement, for it is an everyday experience to see a residue of barium in the lower oesophagus quite unaffected by respiration (Fig. 3). The medium can be rapidly propelled into the stomach by the voluntary act of swallowing. Such a sphincter mechanism may be seen occasionally in conjunction with a hiatus hernia, thus demonstrating that it can function independently of the diaphragm. The radiological appearance is that of a contracted segment about 2 cm. long, quite clearly defined from the wider channel above (Fig. 4).

It is only reasonable to consider that there may be individual variations in the anatomy and physiology of the cardia and diaphragm. For example, Leigh Collis *et al.* (10) made 50 dissections of the diaphragm and found that the oesophageal hiatus was formed by fibres from the right crus in 66 per cent, from the right crus with varying contributions from the left in 32 per cent, and from the left crus alone in 2 per cent. The variations in the physiology of the cardia are shown by the different pressure recordings and the different conclusions reached by independent groups of observers. For the purpose of this paper I propose to follow the work of Sanchez, Kramer, and Ingelfinger (4) because their tentative adoption of the gastro-oesophageal vestibule is supported by some of the radiological appearances seen in both health and disease.

A brief summary of their findings indicates that the terminal eighth of the oesophagus—a segment varying from 2 to 5 cm. in length—has a swallowing complex differing from the rest, for the pressure in the upper seven-eighth rises with swallowing while in the distal eighth it falls. As the final positive wave approaches the cardia, it slows down and terminates in a zone at the junction of the longer and shorter segments. This zone coincides with the estimated position of the inferior oesophageal sphincter and forms the upper boundary of Lerche's gastro-oesophageal vestibule, which is really a new term for the cardiac antrum of the older anatomists. The lower boundary at the junction with the stomach is now known as the constrictor cardiae (Fig. 5).

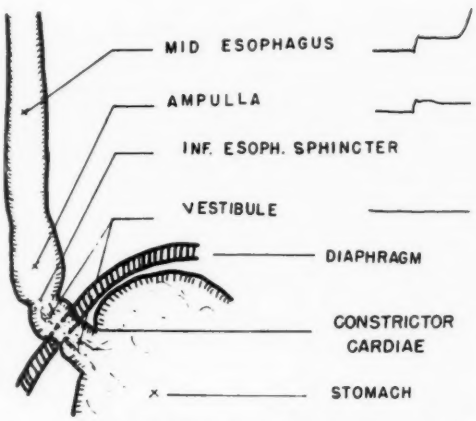

Fig. 5. Diagram depicting the lower oesophagus according to Lerche. (From Sanchez *et al.*, 4.)

The concept of the terminal oesophagus acting differently from the rest of the organ receives some support from Laimer's (11) dissections, which showed in the arrangement of muscle bundles a predominance of spiral and bracket-like fibres in the last few centimeters. Additional evidence may be found in the radiological appearances in certain neuromuscular disorders. For instance, in the characteristic picture of cardiospasm the lumen of the lowest segment or vestibule shows first a short, smooth constriction, then a slight dilatation, before being almost completely obliterated in the terminal 1 or 2 cm. (Fig. 6).

Fig. 6. Classical example of early cardiospasm showing dilatation of the oesophagus above the constriction which is at first short and smooth and then dilates slightly before the lumen is completely obliterated in the terminal 1 or 2 cm. Wall thickening is present.

Fig. 7. Gross distortion of the lower oesophagus due to diffuse spasm. The vestibule and a small pouch of the stomach have been drawn up into the thorax.

Above it the oesophagus is dilated and some irregular, purposeless contractions may be seen.

On the other hand, in diffuse muscular hypertrophy or spasm the vestibule is found dilated while the rest of the lower oesophagus contracts into a series of curious shapes. In the advanced stage of contortion the oesophagus may shorten so much that a small pouch of stomach is dragged up into the thorax and, although it may be possible to fill it with barium from below, reflux into the upper oesophagus does not occur, for the contracted segment acts as a competent barrier (Fig. 7).

Having brought forward some observations in support of the work of Sanchez *et al.* (4), I would like to quote their conclusions:

"In spite of evidence offered by anatomists and the supporting evidence of our pressure records our acceptance of the vestibule as anatomical and functional units is, at best, tentative. Should further studies, however, establish the fact that the vestibule does exist in many people as an anatomical and functional entity, current concepts of hiatus hernia will require revision as it is possible many so called sliding hernias are actually prominent vestibules."

With this statement I entirely agree but would add that the radiologic methods of testing the functional capacity of the cardia, whether they be manual compression, bending, or application of pressure bags, provide a very efficient diagnostic weapon. The repeated—and I emphasize "repeated," for a single instance is insufficient—demonstration of reflux into the oesophagus is such a reliable sign of incompetence that it should be possible to distinguish between hernia and vestibule (12–14).

There is, however, a little more to be learned from the simple roentgenogram of a hiatus hernia but, before proceeding to

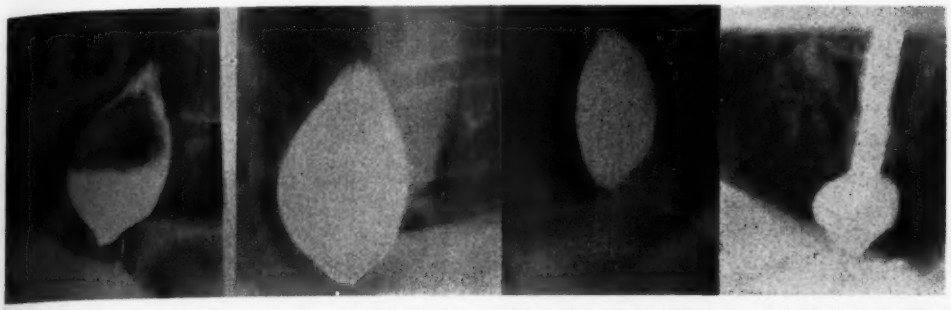

Fig. 8. Series of films taken as barium is swallowed and collects above a tightly contracted diaphragm dilating the lower oesophagus. The apex of the dilatation has a conical shape. The figure at the extreme right shows collapse of the pouch after relaxation of the peristaltic wave. The remaining smaller pouch probably represents the vestibule.

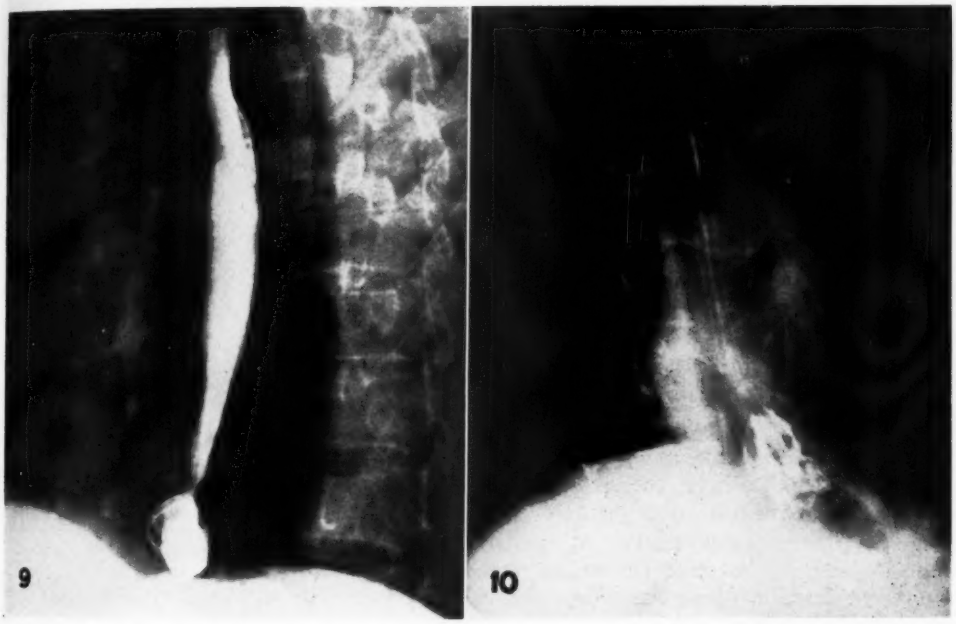

Fig. 9. Pouch found in routine examination, showing a ring-like constriction at the apex and possible gastric folds within the lumen. In this patient there was no evidence of hiatus hernia judged by radiology, pressure measurements, and oesophagoscopy.

Fig. 10. The mucosal pattern of the oesophagus following total gastrectomy. The terminal segment is wider and the mucosal folds are coarser than in the rest of the oesophagus, but at operation no difference in structure was recognized by the surgeon.

examine more closely the formation of a supradiaphragmatic pouch, I would remind you of the action of the diaphragm. In spite of contrary statements based on some pressure records, there is no doubt that the diaphragm can constrict the oesophagus. This is illustrated radiologically when the final wave endeavours to clear barium out of the oesophagus occluded by the tightly contracted diaphragm. The resulting pouch formation has a conical apex and not a ring constriction (Fig. 8). It is widely known as the phrenic ampulla and is excluded from the present discussion since it is artificially produced and its boundaries trespass beyond those of the vestibule. But many times during routine examinations in gas-

Fig. 11. A clip has been applied to the mucosal junction which lay below the hiatal constriction. In the lower oesophagus there is a ring constriction at the upper border of a small dilatation which shows two lateral notches. The clip is not visible and the position is marked.

trointestinal series a small pouch is found just above the diaphragm, which looks exactly like a hernia (Fig. 9). It is bounded above by a smooth ring and sometimes thickened folds resembling gastric mucosa may project into the lumen but, when tests for competence are made, there is no reflux. There is, however, abundant evidence to show that gastric mucosa frequently extends into the lower oesophagus and therefore a well developed vestibule may have a partial or complete gastric mucosal lining (Fig. 10). The lower boundary of the vestibule is lost in the hiatal constriction and it may be assumed that the cardia functions normally because the phreno-oesophageal ligaments maintain the intrinsic sphincter segment in correct relationship to the crura. Thus, the factors which prevent reflux, namely, (*a*) the diaphragm, (*b*) the angle at which the oesophagus joins the stomach, maintained partly by the right crus and partly by the sling fibres of the internal oblique muscle, and (*c*) the intrinsic sphincter mechanism of the vestibule, together with the bunching of the mucosal folds (15), are all in operation.

One example of the gastro-oesophageal vestibule was investigated by oesophagoscopy. The application of a silver clip to the mucosal junction confirmed the concept that the lower boundary lay just at the inferior margin of the hiatus. The roentgenogram (Fig. 11) clearly showed two lateral notches but such an appearance may not necessarily be permanent, for much will depend on the degree of distention (Fig. 12). Sometimes the notches appear to form a shallow continuous ring, which has been described by some authors as a lower oesophageal ring. It is probable that the deformity is produced by the insertion of the phreno-oesophageal ligament and is of no pathological significance. Hypertrophy of the inferior oesophageal

Fig. 12. Roentgenograms taken at the same examination, showing (A) a rounded pouch with ring constriction and apparent gastric mucosal folds in the lumen, resembling a true hiatal hernia, (B) a similar pouch with two lateral notches, like that seen in Fig. 11. No hernia was present. Pouches were considered to be the vestibule with different degrees of distention.

Fig. 13. Bending film showing hiatus hernia and reflux into the oesophagus. The junction of the two structures is well demarcated by a ring-like constriction which is expansile.

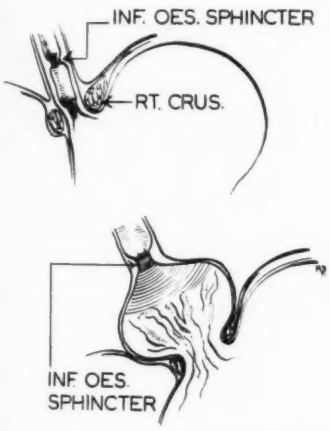

Fig. 14. Diagrammatic representation of the normal position of the vestibule (above) and the change following the development of a hernia (below). The constrictor cardiae now appears widened and the vestibule opens out, fusing with the wall of adjacent stomach.

sphincter, which seems on rare occasions to make a last vain attempt to protect the oesophagus, may produce a broader and deeper ring defect (Fig. 13). This deformity has also been labeled a lower oesophageal ring, but it represents only the sphincter mechanism separating the oesophagus from the gastric pouch of a hiatus hernia. A shelf-like defect with long tapering margins has been shown by MacMahon, Schatzki, and Gary (16) to be caused by a ring of hypertrophied muscularis mucosa over which lay the gastro-oesophageal junction. Of these ring-like defects, only the type described by MacMahon *et al.* appears to be a departure from the usual change with a hiatus hernia. It is felt that the word "diaphragm" might be used for this defect and the term lower oesophageal ring, which has been used to cover a wide group of anatomical and pathological conditions, might be abandoned.

Fig. 15. A small hiatus hernia diagnosed radiologically and confirmed by oesophagoscopy. A clip has been placed at the junction of gastric and oesophageal mucosa and is seen lying a little distance below the constriction ring. The intervening structure is considered to be a dilated vestibule.

When there is a derangement of the anatomical relationship resulting from widening of the hiatus, or laxity of the ligaments, or perhaps abnormal stimulation of the vagi (17), the vestibule slides through the hiatus of the diaphragm, accompanied by a portion of the stomach. As it loses its protective mechanism, the vestibule opens and its walls merge with the adjacent stomach so that the two structures form the pouch of the hiatus hernia (Fig. 14). There

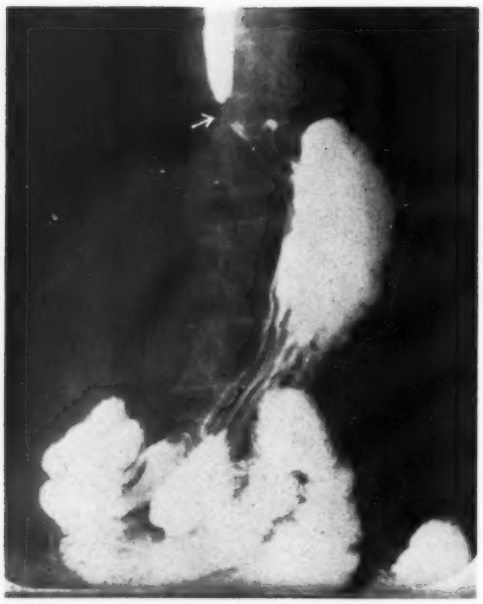

Fig. 16. Roentgenogram of a sliding hiatus hernia taken before it has returned completely to the abdomen. The arrow points to the constriction ring. A small protrusion of greater curvature still remains above the hiatus. Between it and the constriction ring lies the rest of the vestibule.

is support for this hypothesis in a film showing the position of a silver clip placed on the junctional mucosa in a patient with a small hiatus hernia and free reflux. The clip lies clearly above the diaphragm and yet does not coincide with the constriction at the upper boundary of the vestibule (Fig. 15).

Occasionally one finds a similar appearance when a sliding hernia is returning to the abdomen. Figure 16, a film taken before reduction was complete, shows the different segments—first, the lower oesophageal sphincter; next, the remainder of the vestibule; and then a protrusion of the greater curvature.

I would stress again that, whatever conclusions are drawn from pressure recordings, the diaphragm and its ligaments cannot be ignored. Their action in vomiting and belching is, at present, little understood, but Torrance has shown that in the cat a small hernia appears with vomiting and also with vagal stimulation (17). To illustrate the perplexities in man I would

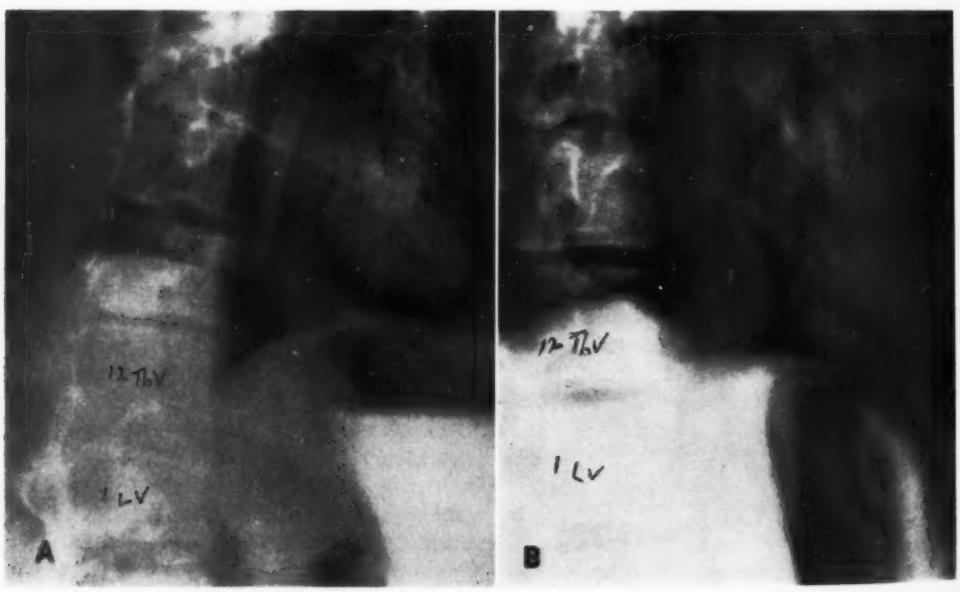

Fig. 17. A. Clip applied to mucosal junction lying in a normal position immediately below the hiatus. It is opposite the upper border of the 12th thoracic vertebra.

B. Roentgenogram taken during belching, illustrating the descent of the domes of the diaphragm, while the position of the clip is almost unchanged. It is not possible to determine the exact position of the oesophageal hiatus.

recall the ruminating youth whose hernia was under complete voluntary control; the man whose hernia appeared only with a belch; and the woman whose hernia could be demonstrated only when she was physically tired. In another patient a silver clip applied to the mucosal junction, which was situated immediately below the diaphragm, remained almost stationary during belching, the principal movements taking place at the diaphragm (Fig. 17). One is tempted to suggest that, as in vomiting, the diaphragm and ligaments may exert some pull on the terminal oesophagus which abolishes the protective mechanism, so that the door is widely opened.

The recent pressure studies of Creamer and Pierce (7) showed that fluid travelled down the oesophagus more rapidly when drunk from a cup than when held in the mouth and swallowed. The difference was ascribed to the inspiratory contraction of the diaphragm which immediately precedes a drink. In response to this movement the vestibule appeared to open.

Finally, to those who assert that the oesophagus is protected only by its intrinsic sphincter mechanism and that radiology is unable to detect the existence of a sphincter, there remains the undisputed fact that a successful repair of a hiatus hernia cures reflux. This criterion can be most efficiently established by radiology. I would emphasize, however, the need for linking radiological observations not only with endoscopy but with pressure recordings. Only in this way is it possible to fit together the pieces of a most stimulating but exasperating jig-saw puzzle.

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SUMMARIO IN INTERLINGUA

Observationes Relative al Anatomia Radiologic del Junction Esophagogastric

Recente studios de pression effectuate al cardia del stomacho ha jectate un certe lumine super su complexe mechanismo, sed le interpretation de ille studios remane ancora controverse. Certe observatores, il pare, mantene que registrationes de pression es superior al technicas radiologic ab le puncto de vista diagnostic. Iste conception es rejicite per le presente autor qui se effortia a correlationar certe

observationes radiologic con studios de pression, specialmente illos de Sanchez, Kramer, e Ingelfinger. Iste tres investigatores accepta tentativemente le notion de un vestibulo gastroesophagee, e isto es supportate per constatationes radiologic in stato de valetude e de morbo.

Le differentias in le responsa al ingluti- tion inter le vestibulo e le resto del esophago es illustrate per observationes in morbos neuromuscular. Le rolo del diaphragma e su ligamentos es sublineate. Es signalate que solmente le coordination de observationes radiologic, de registrationes de pression, e de datos endoscopic va succeder a resolver iste problema.

The Vascular Pattern of the Lung as Seen on Routine and Tomographic Studies[1]

ELLIOTT MICHELSON, M.D., and JULIAN O. SALIK, M.D.

THE ROENTGEN ANATOMY of the lung as seen on routine studies is a composite of contrasting shadows cast by air, blood, bronchopulmonary tissues, and lymphatics. The interpretation of this composite pattern in health and disease is quite reliable, but some limitations are encountered depending upon the site and type of the pathological process. Recognition of the normal and abnormal vascular pattern on tomograms and routine films has proved to be of definite value in the interpretation of lung roentgenograms. In order to evaluate the vascular changes, a basic knowledge of the pulmonary anatomy is desirable. This study endeavors to present the prevailing normal pattern while recognizing that many variations may be found.

Malpighi, in 1661, first described the bronchovascular anatomy of the lung. At the end of the nineteenth century Aeby and Ewart reported a study of the air passages by injection technic, but their concern was primarily with the comparative anatomy of the bronchial tree. It was Ewart who first noted that the pulmonary artery was placed above and lateral to the bronchus, while the pulmonary veins were located below and medial to the bronchus. Miller studied the anatomy of the lung in animals, using stereoscopic films and injection methods, and demonstrated the pattern of bronchial divisions. He noted that the pulmonary arteries accompanied the bronchi, and that the pulmonary veins were at the periphery of the individual lobules of the lung and medial to the corresponding bronchus. Lodge, in his excellent paper on the anatomy of the blood vessels as applied to chest radiology (1946), cites Grieneder as one of the pioneers in correlating the pulmonary vascular pattern by means of tomography (1934). Melnikoff, Felix, and Herrnheiser and Kubat wrote on the vascular pattern of the lung but did not recognize the subsegmental basic units of the organ. Further studies on this subject were made by Hornykiewytsch (1953) and Kováts and Zsebök (1953). The precise anatomical studies of Boyden and Appleton opened the door to more exact diagnosis and treatment, and it became apparent from these studies that there were many variations in the bronchovascular anatomy.

BRONCHIAL ANATOMY

A brief description of the bronchi is necessary as a frame of reference in defining the vascular tree of the lung. As noted in Table I, either the nomenclature recommended by the International Congress of Otorhinolaryngology in London (1949) or Boyden's shorthand numerical system may be used. The trachea (Figs. 1–3) divides at the level of the seventh thoracic vertebra into an oblique left main bronchus and a shorter, more vertical right main bronchus. The right upper lobe bronchus arises a short distance beyond the carina and divides into three segments: apical (B1), posterior (B2) and anterior (B3). Distal to this upper lobe division, the bronchus is crossed by the main trunk of the pulmonary artery. The middle lobe bronchus (B4, B5) arises a short distance beyond, from the ventral wall, and the apical segmental bronchus (B6) of the lower lobe at approximately the same level, from the dorsal wall. The middle lobe bronchus divides to supply the lateral (B4) and the medial (B5) subsegments. From the superior segmental bronchus (B6) arise three sub-

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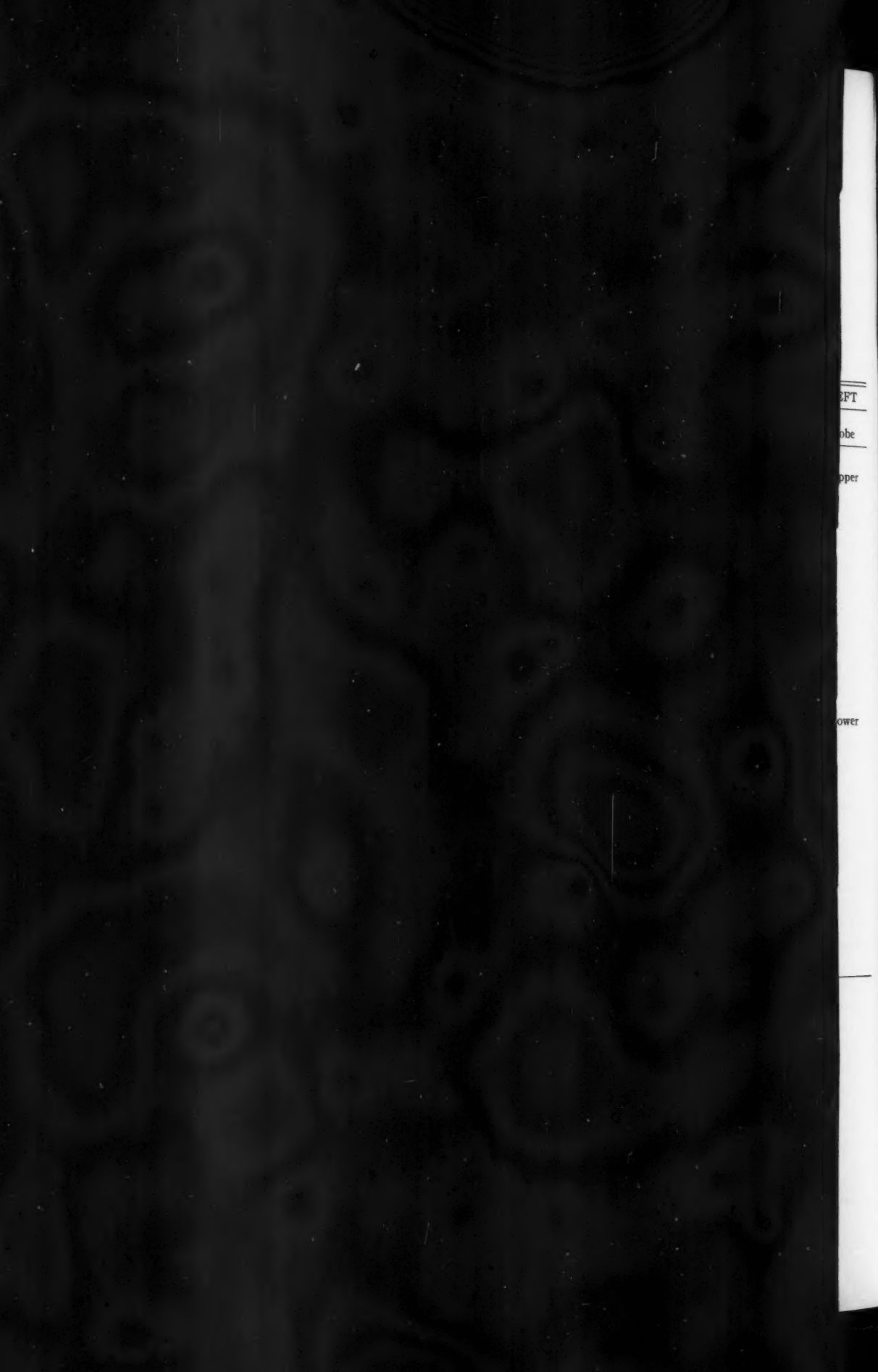
TABLE I. NOMENCLATURE FOR DEFINING BRONCHOVASCULAR TREE

RIGHT						LEFT
Lobe	*Segmental Bronchi* (Boyden)	(International)	*Sub-Segmental Bronchi*	(International)	*Segmental Bronchi* (Boyden)	Lobe
Upper	B1	Apical — B1a, B1b	Apical, Lateral	Apical	B1	Upper
	B2	Posterior — B2a, B2b	Apical, Posterior	Posterior	B2	
	B3	Anterior — B3a, B3b	Lateral, Anterior	Anterior	B3	
Middle	B4	Lateral — B4a, B4b	Posterior, Anterior	Superior lingular	B4	
	B5	Medial — B5a, B5b	Superior, Inferior	Inferior lingular	B5	
Lower	B6	Superior — B6a, B6b, B6c	Medial, Superior, Lateral	Superior	B6	Lower
	B*	Subsuperior		Subsuperior	B*	
	B7	Medial basal — B7a, B7b	Anterior, Medial	Medial basal	B7	
	B8	Anterior basal — B8a, B8b	Lateral, Basal	Anterior basal	B8	
	B9	Lateral basal — B9a, B9b	Lateral, Basal	Lateral basal	B9	
	B10	Post. basal — B10a, B10b	Lateral basal, Mediobasal	Posterior basal	B10	

NOTE TO FIGURES 1–3: The legends for Figures 1, 2, and 3 should read " . . . showing the bronchial tree, pulmonary arteries and veins."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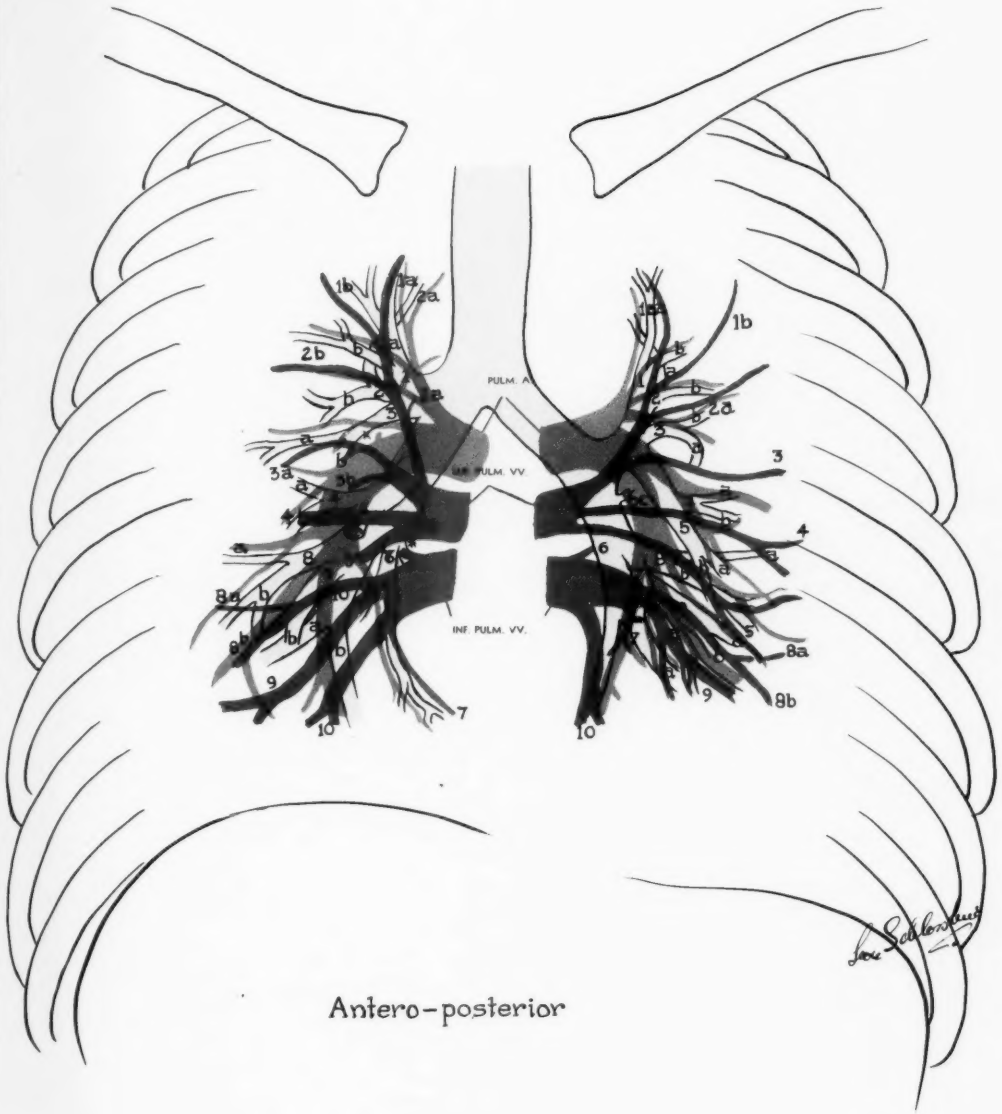

Figure 1. PA view of the chest showing the bronchial tree, arteries, and veins. The bronchial tree is shaded in gray, the arteries in red, and the veins in blue.

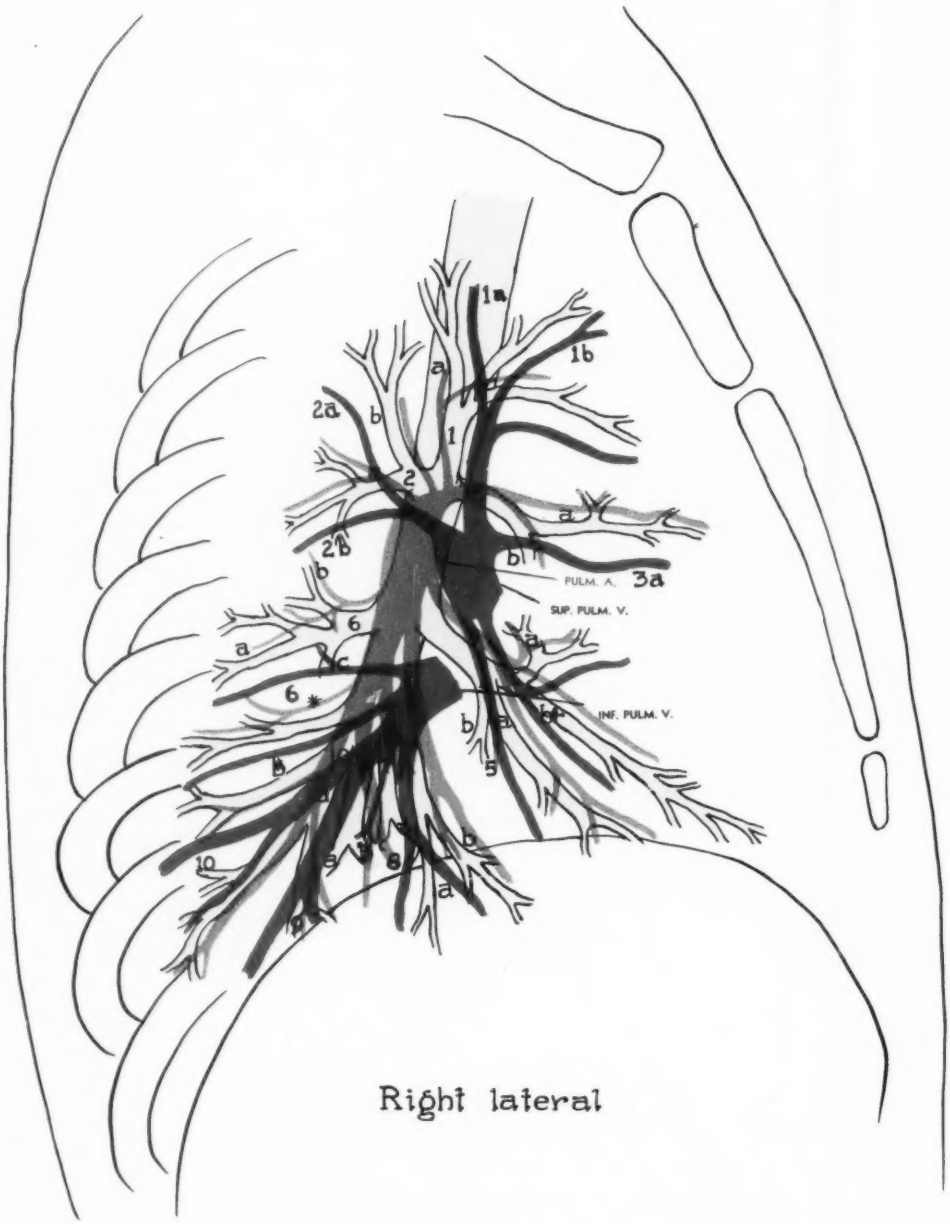

Figure 2. Right lateral view of the chest showing the bronchial tree, arteries, and veins. The bronchial tree is shaded in gray, the arteries in red, and the veins in blue.

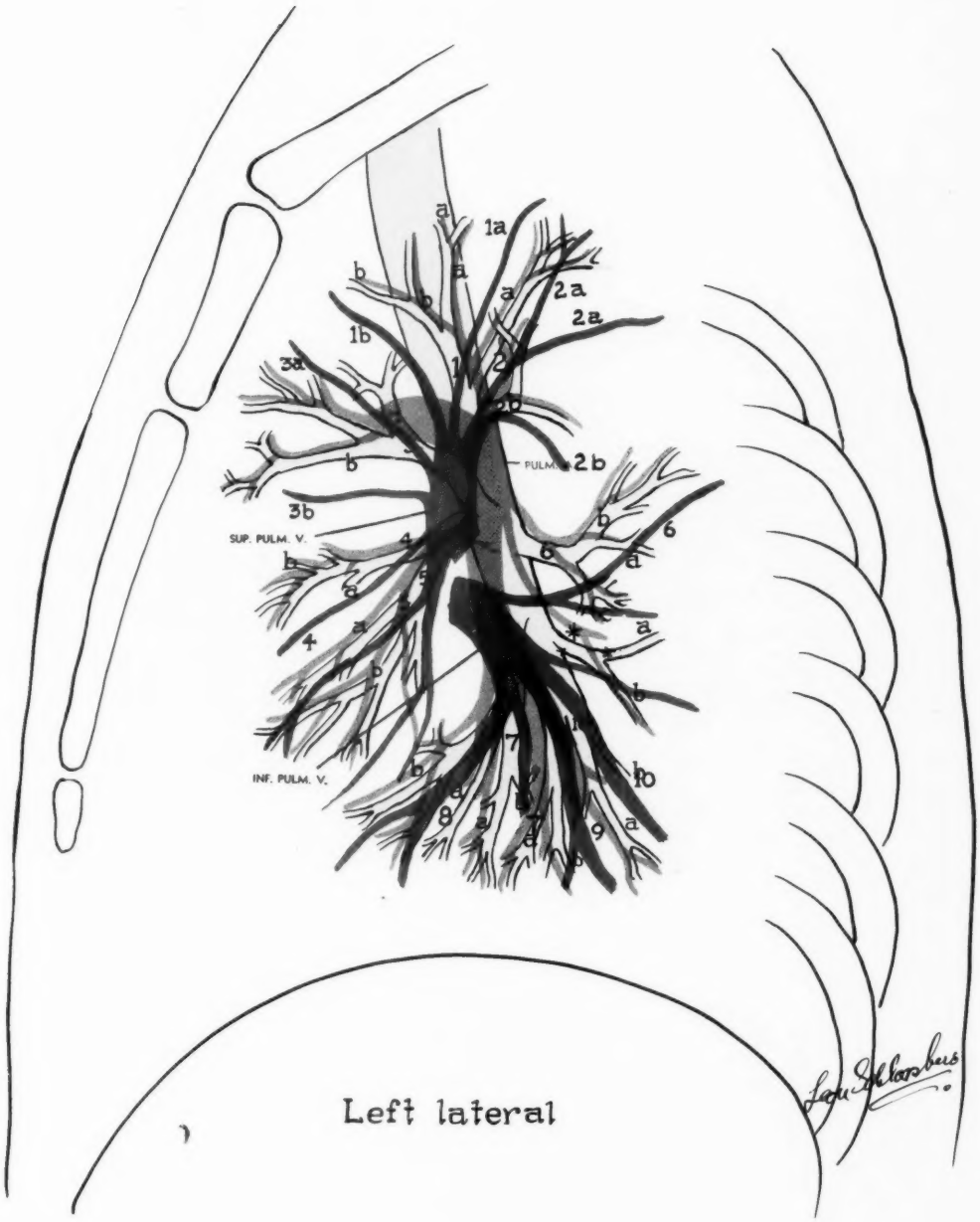

Figure 3. Left lateral view of the chest showing the bronchial tree, arteries, and veins. The bronchial tree is shaded in gray, the arteries in red, and the veins in blue.

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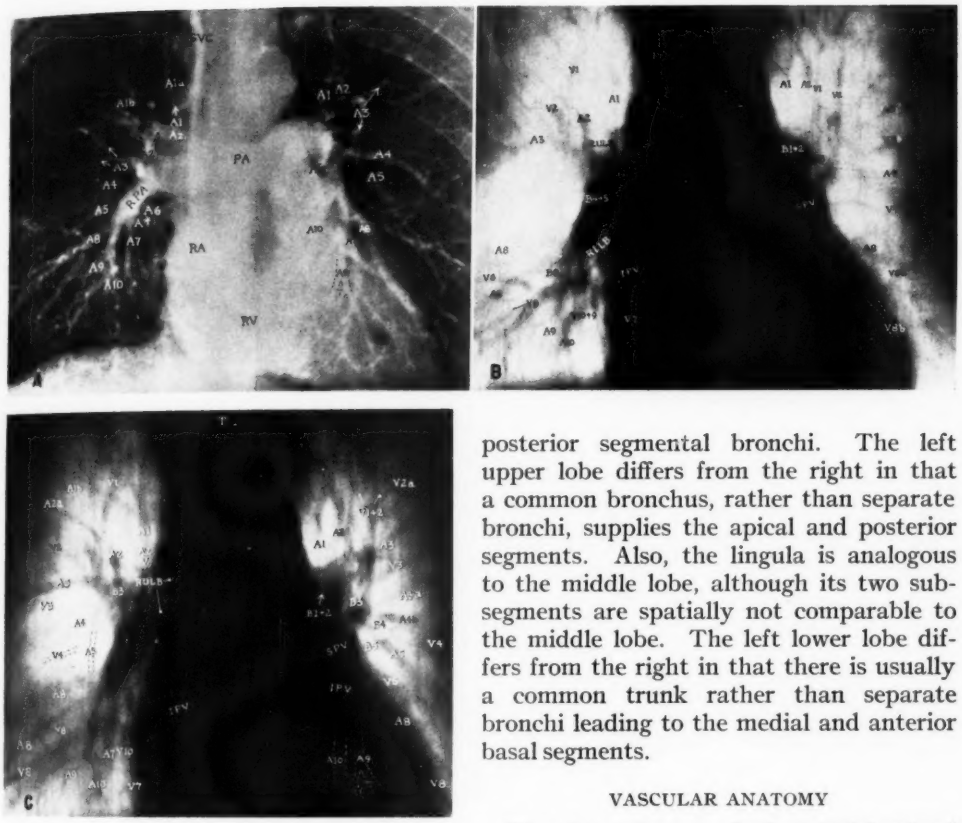


Fig. 4. A. Arteriogram of pulmonary vessels.
B. Tomogram at 10 cm. level. The pulmonary arteries and veins, except the middle lobe vessels, are delineated.
C. Tomogram at 12 cm. level showing pulmonary vessels, including those of the middle lobe.

segments: medial (B6a), superior (B6b), and lateral (B6c). The remaining branches of the lower lobe, the subsuperior (B*), medial basal (B7), anterior basal (B8), lateral basal (B9), and posterior basal (B10) rami, branch successively in that order.

On the left, the pulmonary artery crosses the main bronchus before the left upper lobe division. The left upper lobe bronchus usually bifurcates into the superior and inferior major branches, although in about one-quarter of the cases it trifurcates into the apical-posterior (B1 and 2), anterior (B3), and lingular (B4, B5) bronchi. In more than half of the cases there is a common trunk leading to the apical and posterior segmental bronchi. The left upper lobe differs from the right in that a common bronchus, rather than separate bronchi, supplies the apical and posterior segments. Also, the lingula is analogous to the middle lobe, although its two subsegments are spatially not comparable to the middle lobe. The left lower lobe differs from the right in that there is usually a common trunk rather than separate bronchi leading to the medial and anterior basal segments.

VASCULAR ANATOMY

The lung has a dual arterial blood supply, a low-pressure pulmonary artery, and a systemic pressure bronchial artery. The pulmonary arteries are radiologically visible, but the bronchial arteries are not seen. The pulmonary artery (Fig. 4) divides to the left of the midline just above the carina of the trachea. The right pulmonary artery appears at the hilus in the sixth posterior interspace, passing behind the right superior vena cava. Before entering the lung, it is dorsal and cephalad to the right main bronchus and superior pulmonary vein. The first large branch crosses the anterior aspect of the right upper lobe bronchus and is called the truncus anterior, usually dividing into superior and inferior branches. The inferior division (A3) supplies the anterior segment in almost all cases. The superior branch supplies the apical segment (A1), but may send off a ramus to the apical

portion of the posterior segment (A2a). The posterior segment is supplied by an ascending branch coming off the pulmonary artery below the truncus (A2). Variations of the vascular pattern are more common in the right upper lobe than in any other lobe.

Distal to the truncus anterior, the artery crosses the right main bronchus, entering the interlobar fissure (Fig. 2) and continues downward in this position. At the intersection between the horizontal and oblique fissure, the artery gives rise to one or two arterial branches to the middle lobe (A4, A5), and at this level, or slightly below it, the superior segmental artery (A6) arises. In succession, arteries to the medial basal (A7), anterior basal (A8), lateral basal (A9), and posterior basal (A10) segments are seen. Frequently, these basal segments have not separate arteries but alternating vascular trunks may supply one or more segments.

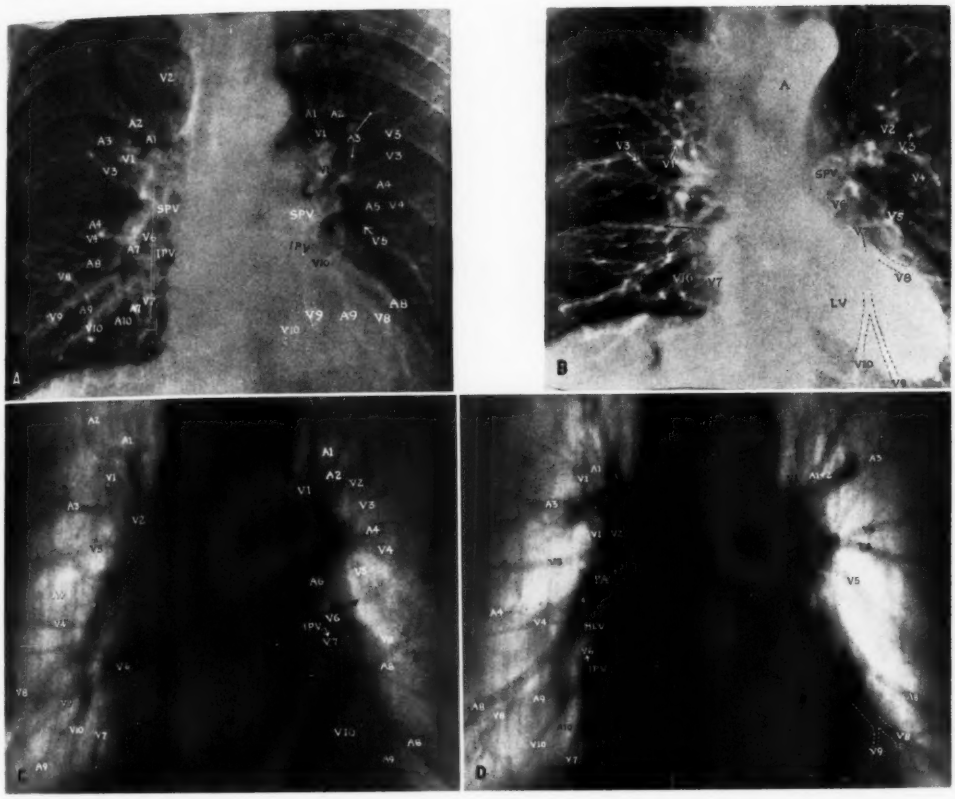
The left pulmonary artery appears at the hilus one interspace higher than its counterpart, passing upward and then looping over the upper lobe bronchus before descending steeply dorsalward in the oblique fissure. There may be one or more arterial branches arising to supply each upper lobe segment. Not infrequently two main trunks are found, the superior being just beyond the arch of the artery and supplying the apical, posterior, and anterior segments. The inferior trunk gives origin to the lingular arteries. As the left pulmonary artery descends in the oblique fissure (Fig. 3), it gives rise to the superior segmental arteries of the lower lobe at a level above that of the lingular arteries. The divisions to the left lower lobe are similar to those on the right.

The veins are more variable than the arteries, but a certain basic pattern can be seen. The pulmonary veins (Fig. 5) enter the hilus on both sides below the artery and are the confluence of the superior and inferior pulmonary veins. The right superior vein drains the upper lobe and usually the middle lobe. On the left, the upper lobe and lingular veins are received in the superior vein. The apical (VI), anterior (V2), and posterior (V3) veins drain the respective segments of both upper lobes. The middle lobe veins (V4, V5) may drain into the anterior segmental vein, enter directly into the auricle, or may even drain into the inferior pulmonary vein. Similarly, the lingular veins (V4, V5) have numerous variations and may empty either into the superior or inferior pulmonary vein. The inferior pulmonary vein is made up of two main branches, a superior basal draining the superior segment (V6) and the common basal draining the remaining segments (V7 to V10).

In the segments proper, the veins course along the periphery, while the artery and bronchus are within the center of the unit. By identifying the vein, one should be able to determine the border of the particular segment, but usually this is not possible. *Veins differ in their course from the artery in describing an arc upward and outward rather than downward and outward and, in so doing, cross the artery and bronchus somewhere within the middle portion of the lung field.* In the lateral projection, the pulmonary vein is seen ventral to the artery and bronchus. Veins usually are of the same caliber as the companion artery, but are straighter with fewer branches, which arise at less acute angles.

SEGMENTAL ANATOMY

Right Upper Lobe: The *apical* bronchus (B1) and artery (A1) are usually well seen on the chest film. The artery (Fig. 6) is always a branch of the truncus arteriosus and is seen as the first division of the large vessel. In about half of the cases, this artery gives rise to a branch of the apical portion of the posterior segment (A2). The apical vein (VI) is also well seen, lying lateral to the artery in the anteroposterior projection. The vein drains the apical segment exclusively in about one-half of the cases but may receive the apical portion of the posterior segmental venous blood.



Figs. 5. A and B. Angiogram showing the pulmonary venous phase.
C. Tomogram at 9 cm. level. Note the veins at this level.
D. Tomogram at 11 cm. level showing fairly clearly the middle lobe veins. Note the middle lobe vein (V4) entering the left atrium separately.

The *posterior segmental* bronchus (B2) may be quite small or even absent, in which case this segment is assimilated by portions of the apical (B1) and anterior segmental (B3) bronchus. It is usually supplied by a recurrent branch from the apical artery plus an ascending branch from the pulmonary artery proper (A2). There are numerous variations, which include a branch coming from the superior segment of the right lower lobe. The posterior vein (V2) routinely is demonstrated only in the lateral projection.

The *anterior segment* is usually the largest segment of the upper lobe. The arterial supply always comes from the inferior division of the truncus arteriosus (A3). The anterior vein (V3) is usually well seen on the anteroposterior view, draining directly into the superior pulmonary vein. Occasionally, the vein may drain the middle lobe veins or the posterior vein.

Right Middle Lobe: The right middle lobe bronchus and its lateral (B4) and medial (B5) subsegments are seen only in the more ventral levels of the tomogram. One or two arteries (A4, A5) are present, and there is no correlation between the arterial and bronchial pattern. In the anteroposterior projection, A4 (Fig. 5D) is usually seen, but A5 is hidden by the mass of the pulmonary artery. In the lateral projection (Fig. 7) all middle-lobe arteries are usually seen. One or two veins (V4, V5) may be present and these drain into the superior pulmonary vein. Infrequently, drainage is directly into the

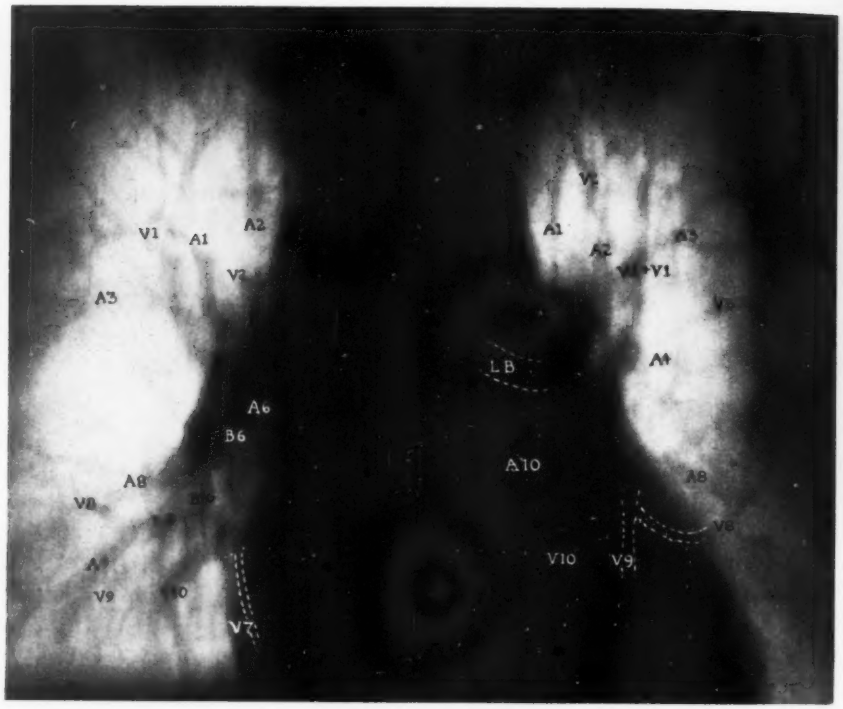


Fig. 6. Tomogram at 9-cm. level, showing well defined upper lobe vessels.

auricle or into the inferior pulmonary vein. The venous system is usually not well demonstrated on the anteroposterior view but, can be observed on the lateral projection.

Right Lower Lobe: There are three subsegmental divisions of the *superior segment* of the lower lobe: the medial (B6a), the superior (B6b), and lateral (B6c). The segmental artery (A6) can be seen on a lateral but not on an anteroposterior film. The vein (V6) (Figs. 5c and 7) drains into the superior basal vein and may be noted in both anteroposterior and lateral projections.

The right lower lobe bronchus division gives off separate trunks to the *basal segments:* subapical (B*), medial basal (B7), anterior basal (B8), lateral basal (B9) and posterior basal (B10). The basal segmental arteries may arise in sequence or develop from two main trunks, an upper (A7–A8), and a lower (A9–A10). The common basal vein (Fig. 4B) is formed by the union of the superior basal, which drains V8 and V9 and the inferior basal (V10). V7 drains the medial basal segment and enters the inferior pulmonary vein (Fig. 5D and 7). These veins can be seen in both postero-anterior and lateral projections.

Left Upper Lobe: In the *apical posterior segment* a single bronchus may divide into two segmental branches (B1, B2) or separate segmental bronchi may be present. Each segment is supplied by two or more arteries (A1, A2). There is one large apical vein (V1 + 2) which drains the apical and posterior segments. On the anteroposterior projection, the artery and vein are usually seen (Fig. 6).

The artery and vein to the *anterior segment* (A3, V3) (Fig. 5D and 8) are usually seen on both anteroposterior and lateral projections. In almost half of the cases, there may be vascular branches

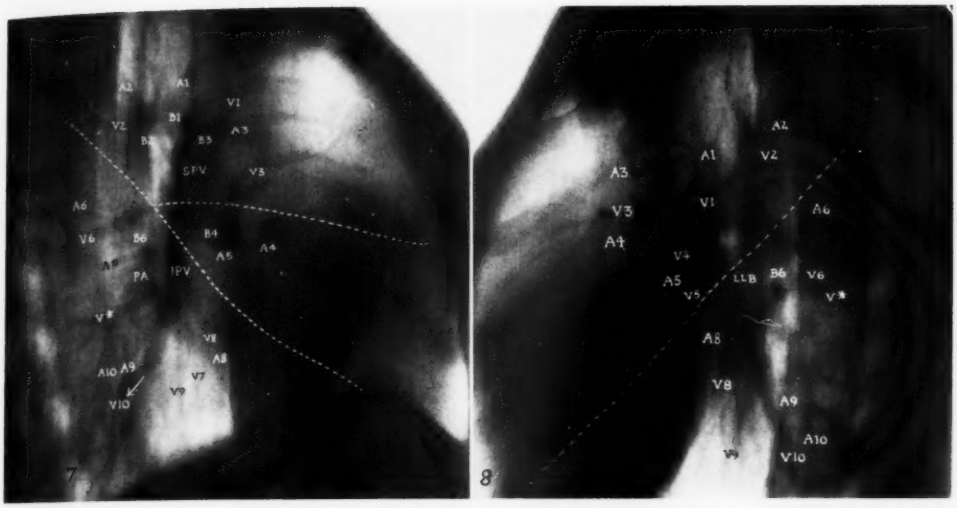


Fig. 7. Right lateral tomogram at 11 cm. level, showing well defined vascular pattern. Note the fairly distinct middle lobe vessels.
Fig. 8. Left lateral tomogram at 10 cm. level, delineating the vascular pattern including the lingular area.

going to this segment from the apical segment above and the superior lingular vessels below.

The *lingular* bronchus divides into the superior (B4) and inferior (B5) subsegmental stems. The arteries (A4, A5) are usually well defined (Fig. 4C), although occasionally they may receive blood from the medial basal artery of the lower lobe (A7). The lingular veins (V4, V5) (Fig. 5D) drain into the superior pulmonary branch, but in about 10 per cent of the cases, drain into the inferior pulmonary vein. The lingular arteries can be seen on both anteroposterior and lateral projections (Figs. 4C, 5D, 8) but the veins are best delineated in the lateral projection.

Left Lower Lobe: There is no difference between the right and left lower lobes except for the increase in size of the left superior segment.

DISCUSSION

Tomography is an important diagnostic modality in that it delineates shadows within a thin segment of tissue. In the anteroposterior tomograms taken on average patients, the greater part of the bronchovascular pattern can be seen at levels from 8 to 12 cm., counting from the back. The middle lobe and lingular segment are seen at more anterior levels. The bronchi should be visible as far as their segmental branches, but one can see only arteries and veins beyond this point. In this paper no attempt has been made to classify the divisions of the vessels beyond the subsegmental branches. If the normal architecture is known, it should be possible to determine lesions which modify the position, the arborization or the caliber of the vascular system. For example, in some altered hemodynamic states the peripheral vessels may be invisible either generally or locally. While there is a great deal of variation in the vascular lung pattern, the basic picture is easily recognized and, after a close study of the vascular tree by tomography, it is surprisingly easy to trace a great number of vessels on routine postero-anterior and lateral chest films. Study of oblique films will reveal the same obvious pattern (Fig. 9, A and B).

The pulmonary arteries arch downward from the hilus producing a weeping willow pattern. The pulmonary veins enter the

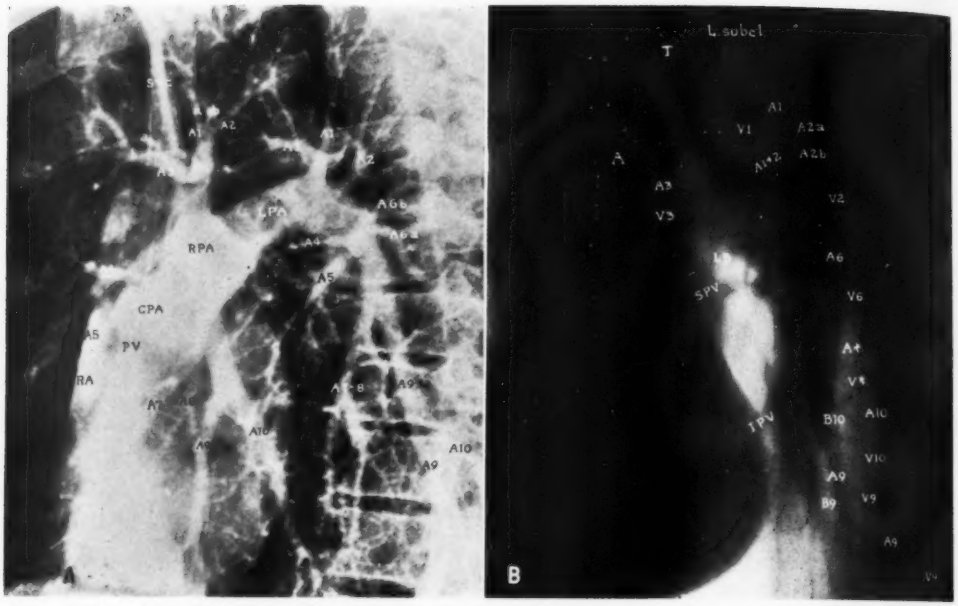


Fig. 9. A. Left anterior oblique angiogram. B. Left anterior oblique tomogram at 12 cm. level.

mediastinum below the arteries and their course to some extent describes a reverse arch to the arteries giving the appearance of a zodiac crab. The veins produce a very characteristic design, being straighter than the arteries with branches at less acute angles. In the segmental plane the vein is either lateral or inferior to its corresponding artery. *Since the vein and artery cross at right angles, the differentiation can be made by following the course of the vessel back toward the hilus.*

On the conventional postero-anterior and lateral chest films the majority of segmental arteries and veins can be identified (Fig. 10, A, B, C). In the right upper lobe the apical (A1, V1) and anterior (A3, V3) segmental arteries and veins can be seen. Lateral branches (A2a, V2a) of the posterior segment are usually recognized. In the middle lobe usually only the medial vessels (A4, V4) are demonstrated, but in the lateral view both segmental vessels (A4, A5, V4, V5) are observed. The left upper lobe arterial branches to the apical posterior (A1, A2, V1, V2) and anterior (A3, V3) segments usually present a shrub-like appearance, but they can be identified if followed into their respective segmental areas. A large vein (V1-V2) can be seen extending upward, lateral to the segmental arteries. The lingular vessels (A4, A5, V4, V5) are almost always recognizable in the postero-anterior and lateral projections. In both the right and left lower lobes the arteries to the basal segments (A7 to A10) can be seen, but the superior segmental arteries (A6, A*) are not easily recognized. The venous pattern of the right lower lobe is well defined, but the dense cardiac shadow generally obscures the left lower lobe veins on the film.

SUMMARY

After some experience with tomographic localization of pulmonary structures, most of the vascular pattern can be identified on routine postero-anterior and lateral films. This knowledge is valuable in appreciating the great spectrum of pathological changes, congenital or acquired. Examples of normal vascular architecture are noted and described. By using the

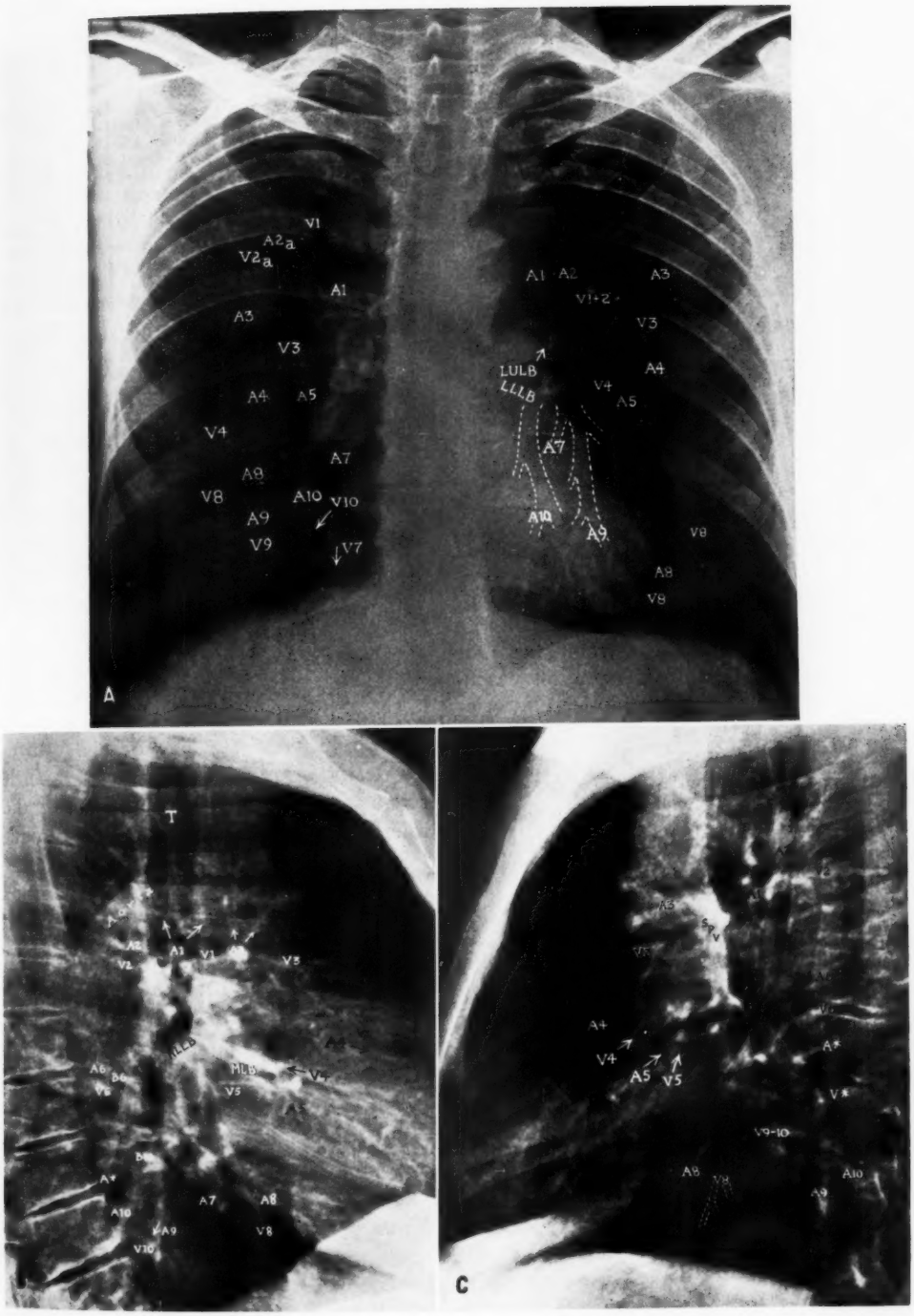


Fig. 10. A. Routine postero-anterior chest film in which a great number of segmental veins and arteries can be identified.
B. Routine right lateral chest film in which some of the vascular pattern can be discerned.
C. Left lateral chest film with some of the vascular pattern visible.

basic vascular pattern in tomograms as a guide, most of the arteries and veins can be recognized on the conventional film.

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SUMMARIO IN INTERLINGUA

Profilos Vascular del Pulmon, Vidite in Roentgenographia Routinari e Tomographic

Post que on ha acquirite un certe experientia in le localisation tomographic de structuras pulmonar, on trova possibile identificar le majoritate del profilos vascular in pelliculas routinari postero-anterior e lateral. Isto es de importantia pro le appreciation del grande spectro de alterationes pathologic que pote occurrer.

Ben que il ha multe variationes in le profilos vascular del pulmon, le structura fundamental es facilemente recognosc te. Le arterias pulmonar forma un arco descendente ab le hilo, con le effecto visual de un salice plorante. Le venas pulmonar entra in le mediastino infra le arterias, e lor arco es in un certe maniera le reverso de illo describite per le arterias, con le effecto visual del Cancere zodiacal. Le venas produce un configuration characteristic, illos es plus recte que le arterias, e le angulos de lor brancas es minus acute. In le plano segmental, le vena se trova lateral o inferior al arteria correspondente. Proque le vena e le arteria se transversa mutualmente in un angulo recte, le differentiation pote esser effectuate per sequer le curso del vaso in retro verso le hilo.

Current Technical Problems in Cinefluorography

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THE RADIOLOGIST who has done cinefluorographic examinations undoubtedly has learned from experience that there are many ways in which the equipment could be improved. For him this paper may suggest some ideas for future developments in the field of cinefluorography. The radiologist who hopes to do cinefluorography should not be discouraged by the problems presented because it is only in the past two or three years that some components of the cinefluorographic system have been studied with vigor. This increased interest in developing better equipment should produce more efficient apparatus within the next three to five years.

The cinefluorographic unit is actually a system composed of several components: namely, an image intensifier, some lenses, and a movie camera with movie film. The camera and film are noted separately because there are problems connected with each. All of these components must operate with optimum efficiency and the entire system must be integrated into an already complex x-ray control and generator unit. Dr. Robert E. Hopkins, Professor of Optics at the University of Rochester, recently commented that all of the cinefluorography system components had been forced to an operation level near the upper limit of efficiency and that a systems engineering type of analysis would now be helpful. This approach seems reasonable. Although each component of the system needs development, further work should be done to find the best means for coupling the parts. For instance, is a lens system the best device for focusing the image intensifier output onto the movie camera lens? Would a fiber optics system be more efficient? Dr. Hopkins suggested that it might be. Technical problems such as these were discussed at the recent Symposium on Cinefluorography. The Proceedings of the Symposium (1) will be an excellent reference source for the radiologist who is interested in this field.

Because the image intensifier is important to the radiologist for both cinefluorography and fluoroscopy, I have chosen to confine my comments to the development status of this component.

THE IMAGE INTENSIFIER PROBLEM

In the 1941 Carman Lecture, Dr. W. Edward Chamberlain (2) showed that for fluoroscopy of the abdomen, the light level on the fluoroscopic screen varied between 0.0001 and 0.001 millilamberts. For optimum critical viewing of a roentgenogram, a light level of 10 to 30 millilamberts is needed. It seemed that an image intensifier with a gain of 10^4 or 10^5 was just what was needed. Morgan, however, from his extensive studies on screen intensification, concluded that photon fluctuation would impose a serious limitation on the clarity of vision. In an excellent review in 1956 (3) he noted that an intensifier would not improve the clarity of fluoroscopic vision if it only increased the brightness of the fluoroscopic screen without increasing the efficiency of roentgen ray photon utilization over that which occurred at conventional fluoroscopy. He concluded that, if the eye used 100 per cent of the information carried from the patient to the screen, no increase in clarity could be expected under any circumstance.

Coltman (4, 5) also has been interested in this problem. His recent work demonstrated that an image intensifier which was limited in resolution only by the scintillation effect (photon fluctuation) could outperform screen-film radiography by a sizable factor. He determined this by counting

[1] From the Department of Radiology, University of Rochester School of Medicine and Dentistry, Rochester, N. Y. Presented as part of a Symposium on Cinefluorography in Medical Practice at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16–21, 1958.

the number of information-bearing x-ray quanta at the fluoroscopic screen for phantom thicknesses ranging from 6 to 26 cm. Then he observed the number of scintillations required by an observer for recognition of a 10-line pattern in a square at various contrast levels. These data are as follows:

Background Population Flashes per Second	*Contrast Required to Perceive 10 Lines in a Square*
900	100%
2,000	70%
5,000	50%
12,500	35%
50,000	20%
130,000	14%
270,000	10%

At high brightness and contrast levels the eye cannot achieve resolving powers much greater than 12 lines per millimeter. Under the conditions set up for the experiment, Coltman determined that the eye resolution limit would be reached before the image intensifier scintillation limit.

Contrast levels below 10 per cent need more investigation. Bouwers (6) in a recent paper discussed the problems of low contrast and proposed a condition of perceptibility which he defines as

$$cd\ (D)^{1/2} = 1$$

where

c = contrast in percentage
d = object size (diameter in millimeters)
D = milliroentgens at the screen

According to this formula, 100 milliroentgens at the screen would be required for perception of an object 1 mm. in diameter at 10 per cent contrast level. To perceive a smaller object at the same contrast level, the number of milliroentgens must be increased.

This is an important point for the radiologist to understand. We have now reached a stage in the development and application of image intensifier systems which permits one to decide what detail is necessary and sufficient for diagnosis in various types of examinations. It is obvious that, if reduced detail can be accepted, then the milliroentgens required can be less (10).

This background material shows that the central problem in image intensifier development remains unchanged—namely, to increase the efficiency of utilization of the information-bearing roentgen ray photons. At a two-day symposium on image intensifiers sponsored by the Army Engineer Research & Development Laboratories (October 1958, Fort Belvoir, Va.) the latest research work was described for three types of intensifiers: the image converter tube, the television system, and the light-amplifier panel.

The Image Converter Tube: To get a greater gain from an image tube, one might guess that multiple stages of amplification could be used. However, the distortion in the electrostatic lens system is severe, and superimposing stages of amplification increases this distortion. In an experimental two-stage tube with a 2-inch diameter input phosphor, the resolution at the center of the output phosphor is 18 lines/mm., while at a distance of 6 mm. from the center the resolution is 4 lines/mm. Magnetically focused image tubes can show a higher resolution of 40 lines/mm. at the center of the output phosphor and 20 lines/mm. at 1 inch from the center. Because of construction problems, image tubes with magnetic focusing are usually limited to 1 or 2 inches in diameter. It is interesting to note that the nuclear physicists have gain and resolution requirements for image tubes that are similar to the requirements of the radiologist. For instance, the physicist wishes to use the image tube to photograph an event taking place in 10^{-8} seconds. He would like a brightness gain of 10^5 and a resolution of 10 lines/mm. The nuclear physics group at the University of Michigan have devised an ingenious method for obtaining high gain, using two commercial 5-inch diameter image tubes. The two tubes are used in a flip-flop, gated circuit in which the light pulse is fed from the output of the first tube to the input of the second tube. The

second tube output is fed back to the input of the first tube and after 10 round trips a light flux gain of 1.9×10^6 is obtained. This system is not directly applicable to cinefluorography, but the radiologist will undoubtedly benefit by the nuclear physicists' interest in image tube development.

The Television System: The problem of increasing the efficiency for both the vidicon and image orthicon type tubes is receiving much attention. Better tube surface layers have been made to increase conversion efficiency of x-rays to electrons. Progress has also been made in producing thin film electron-conducting targets with high secondary electron emission.

Of the intensifier systems now available, only the television type can supply high level light output. In general, however, the resolution of the television system is not as great as that of the image tube. For a 12.5-inch diameter input screen scanned by 525 lines at 30 frames per second the resolution is about 40 lines per inch or about 1.5 lines/mm. This amount of resolution is satisfactory if 16-mm. film is used for recording the television picture. Jacobs (7) has stated that for a television system with equal horizontal and vertical resolution and with a 4 to 3 aspect ratio there are 210,000 distinct picture elements per frame. For 16-mm. film properly exposed and processed there are approximately 250,000 distinct elements per frame.

The Light Amplifier Panel: The most convenient form for an intensifier would be a panel. The interesting development work now in progress on light amplifier panels has been described by Kazan (8, 9), who demonstrated a model solid state amplifying fluoroscope screen to radiologists in 1957. One type of light amplifier panel (9) uses 420-cycle operation and requires 1 foot-candle-second to trigger an image on. The light gain is approximately 100 and the resolution is about 40 lines per inch. When desired, the panel image can be erased by electrical means without the delay normally required by the decay of the photoconductor. Unfortunately, the panels do not at present have the characteristics needed for cinefluorography or fluoroscopy, but radiologists could begin experimenting with these panels by putting them in cassettes in place of the intensifying screens.

THE RADIOLOGIST AND CINEFLUOROGRAPHY

The radiologist, when first confronted with the problem of setting up cinefluorographic equipment, is usually unsure on how to proceed. He sees an electronic, optical, camera system completely different from his familiar x-ray unit. He wonders whether he should buy the intensifier now available or whether he should wait to see what next year's development will be. And he usually has no way of evaluating his needs with respect to the different types of cinefluorographic equipment.

To help the radiologist solve his problem, Dr. George H. Ramsey recently suggested that several radiology departments might co-operate with the manufacturers to make clinical tests of cinefluorographic equipment. The radiologists would compare the characteristics, such as gain and resolution, of different types of equipment, and would make extensive performance tests. Their results would be presented to all interested radiologists and engineers at a meeting jointly sponsored by radiologists and equipment development companies. The published material from the meeting would help a radiologist to decide what cinefluorographic equipment he needed. The Warfare Vision Branch, Army Engineer Research and Development Laboratories, has an extensive testing program for evaluation of image intensifier performance. Radiologists need a similar testing program for cinefluorographic equipment.

SUMMARY

Some current development problems concerned with image converter tubes, light amplifier panels, and television intensifier systems have been discussed. A testing program is suggested to help supply performance data on various types of cinefluorographic equipment.

NOTE: Since this article was written, an excellent discussion of radiological enhancement methods has been published by Jacobson and MacKay (10).

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SUMMARIO IN INTERLINGUA

Currente Problemas Technic in le Cinefluorographia

Recente meliorationes del apparatura ha augmentate le utilitate clinic e experimental del cinefluorographia. Tamen, multe labor remane a facer pro augmentar le efficacia del systema cinefluorographic. Proque le intensificator de imagine es importante tanto pro le cinefluorographia como etiam pro le fluoroscopia, le autor ha dedicate su attention a ille componente. Hic le problema central es augmentar le efficacia del utilisation del photon roentgenoradial. Es presentate breve revistas de currente recercas relative a tubos conversori, systemas de intensificator televisional, e pannellos de amplificatores de lumine. Es proponite un programma de cooperation inter un numero de departimentos de radiologia e le fabricantes pro le evalutation experimental del efficacia de componentes cinefluorographic.

An Approach to Biplane Cineangiocardiography

3. Early Clinical Observations[1]

HERBERT L. ABRAMS, M.D.

THE APPLICATION of special studies to the diagnosis of heart disease is now more extensive than ever before. In addition to broadening our understanding and strengthening our clinical appraisal of many types of cardiac malformations, such studies serve to separate the operable from the inoperable patient, and to give the surgeon a clear concept of the problems confronting him as he opens the heart.

This report summarizes, as a part of this symposium, impressions gained from a limited experience with a biplane cineangiocardiographic technic applied to clinical problems.

METHOD AND MATERIAL

The background, objectives, equipment, and technic of our approach to biplane cineangiocardiography have been described in detail (1, 2). At this time, clinical problems in 44 patients have been analyzed.

Most patients, but not all, were referred with congenital anomalies sufficiently distressing so that they were candidates for definitive heart surgery. The age range was from six weeks to forty years. In all cases, biplane cinerecording was performed following intracardiac injection of the opaque medium through a catheter. Cinestrips were analyzed both as individual frames side by side and as continuous motion pictures in sequence. The 35-mm. film was usually reduced to 16 mm. positive, which could then be studied at the same time as the 35-mm. strips. In some instances, anteroposterior and lateral projections were printed side by side on 16-mm. film, but simultaneous analysis of the events occurring in two projections was difficult.[2]

Forty-four Cases Studied by Biplane Cineangiocardiography

Normal	2
Acyanotic	
Atrial septal defect	1
Ventricular septal defect	6
Pulmonic stenosis and ventricular septal defect (left-to-right shunt)	3
Corrected transposition with ventricular septal defect	2
Patent ductus arteriosus	3
Coarctation	3
Cyanotic	
Tetralogy of Fallot	2
Pulmonic stenosis with patent foramen ovale	1
Transposition	2
Transposition with pulmonic stenosis	1
Transposition with tricuspid atresia	1
Tricuspid atresia	1
Trilocular heart	3
Eisenmenger complex	1
Miscellaneous	
Mitral insufficiency	3
Partial malrotation	1
Dextrocardia	1
Aortic arch anomaly	1
Fibroelastosis	2
Ventricular aneurysm	1
Aortic insufficiency	1
Aortic stenosis	1
Unsatisfactory	1

RESULTS

From the point of view purely of diagnosis, virtually all studies were satisfactory. The contrast was generally quite good. Film graininess was annoying, but certainly not a deterrent to accurate

[1] From the Department of Radiology, Stanford University School of Medicine, San Francisco, Calif. Supported by a Grant (H-4043) from the National Heart Institute of the National Institutes of Health, U. S. Public Health Service.

Presented as part of a Symposium on Cinefluorography in Medical Practice at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16–21, 1958.

[2] There was simply too much information to be digested efficiently when biplane movies were studied simultaneously.

evaluation. Detail was fair, although not equal to that obtainable with a 5-inch intensifier, in which a smaller image is photographed on all of the 35-mm. frame, and certainly not comparable to detail on conventional large film studies. Initially, the procedures were cumbersome and time-consuming. With increasing experience, they now run smoothly and without undue investment of time and personnel. During the period of increasing familiarity, there were very definite failures, requiring second examinations. These occurred largely during the early dog studies. Almost always they were based on human error rather than on equipment breakdown. The ability to utilize Dynapulse timing, a major advantage of the installation, was limited to children and young adults weighing less than 130 to 140 pounds.

A few comments on specific studies are called for:

1. *Normal* (Fig. 1): The normal cine-study following intracardiac injection demonstrates not only the position of the tricuspid and pulmonic valves, but also their range of motion. The residual volume of the right ventricle is small. Transit through the lungs and venous return to the left atrium are accompanied by a faint but unmistakable "lightening" of the normally darkened lung fields. The left atrium usually contains a significant amount of residual blood, while the left ventricle in man, unlike that of the dog, expels virtually all of its contents with systole. The sinuses of Valsalva and the coronary arteries may be seen with aortic filling, but the valve cusps are difficult to delineate.

2. *Left-to-Right Shunts:* With right cardiac injection, atrial and ventricular septal defects are readily recognizable both by demonstration of negative jets of nonopacified left heart blood in the early phases, and by reopacification in the late phases. In patent ductus arteriosus, the "blanching" phenomenon (4) and late refilling are clearly seen. If the injection is made into the left atrium or the left ventricle, the precise anatomy of the septal defect may be shown.

3. *Pulmonic Stenosis:* With right ventricular injection, the anatomy of the outflow tract of the right ventricle and of the pulmonic valve can usually be precisely delineated. The degree of work hypertrophy of the right ventricle can be roughly assessed.

4. *Right-to-Left Shunts:* The tetralogy of Fallot, tricuspid atresia, transposition of the great vessels—indeed all of the "cyanotic" anomalies—can be admirably studied by the cinemethod. With left heart injection in tricuspid atresia, the diminutive right ventricle may be demonstrated *via* the ventricular septal defect, and the origin of the circulation to the lungs may be shown. In transposition, initial injection into the right heart demonstrates the continuity of the aorta and the right ventricle, and subsequent injection into the left cardiac chambers demonstrates the filling of the pulmonary artery from the left ventricle, with recirculation to the left atrium after passage through the lungs.

Two special situations deserve comment:

(*a*) *The Eisenmenger Complex* (Fig. 2): A young man was sent to us with a diagnosis of primary pulmonary hypertension. He had had dyspnea, but no visible cyanosis or clubbing, and was moderately incapacitated. Cardiac catheterization performed elsewhere demonstrated pulmonary artery and right ventricular hypertension, with no evidence of left-to-right shunt. The catheter did not pass through a septal defect or a ductus arteriosus. Biplane cineangiocardiographic study was performed, with an injection of the opaque medium into the right ventricle. The right ventricle was enlarged and trabeculated. There was faint premature opacification of the aorta, seen in the frontal projection. In this projection the exact site of right-to-left shunt could not be delineated, although reversed ductus flow was excluded by visualization of the ascending aorta. In the lateral projection, however, a definite but transient shunt

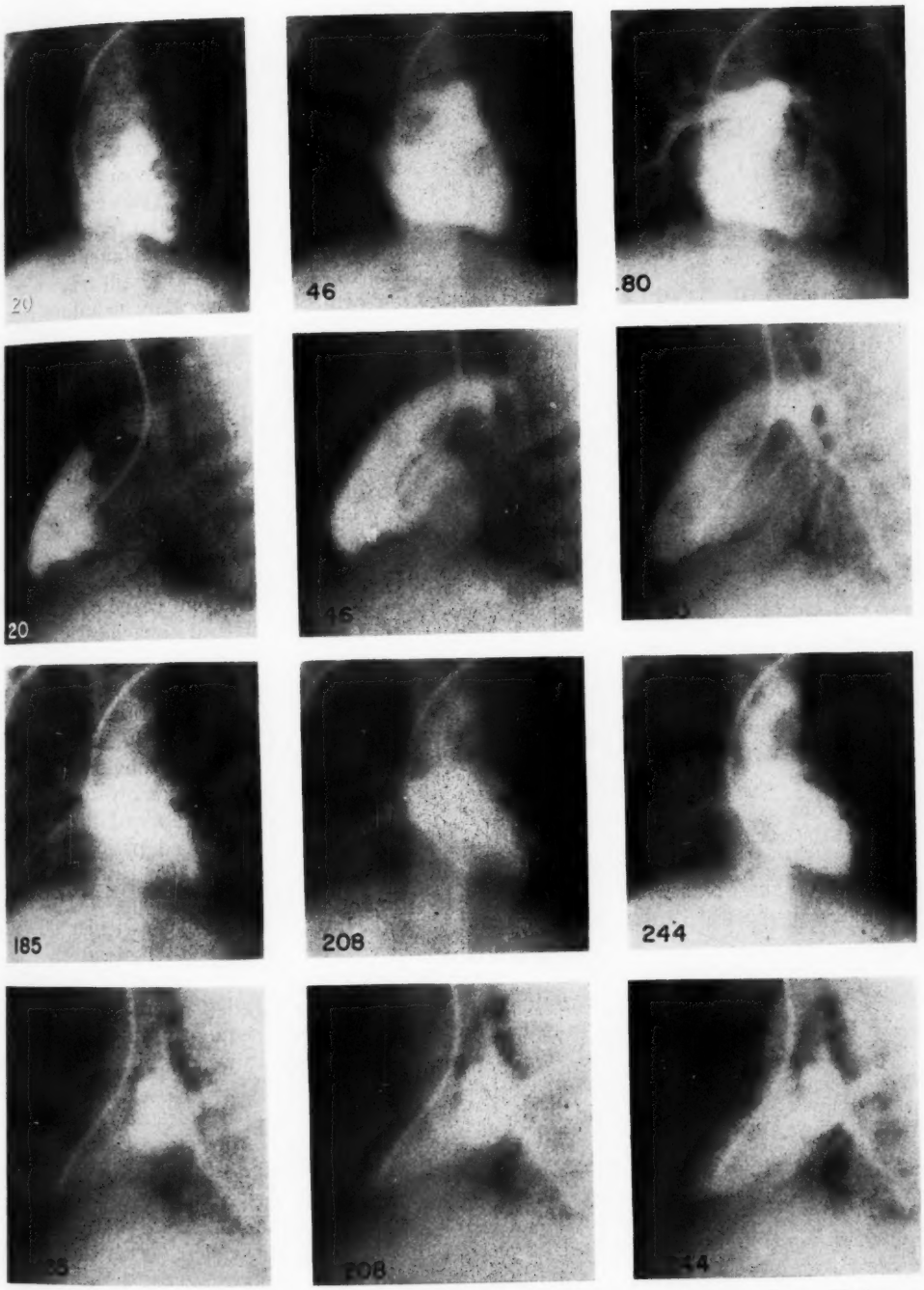

Fig. 1. Normal biplane cineangiocardiogram. Anteroposterior and lateral projections. Frame 20 demonstrates right ventricular injection, and the subvalvular area is clearly demarcated. In frame 46, reflux through the tricuspid valve into the right atrium is visible, and by frame 80 the opaque medium has spread into the pulmonary arteries. In frame 185, the pulmonary veins are opacified and there is filling of the left atrium. Notice the difference in size of the left atrium in diastole (frame 208) and in systole (frame 244). Conversely, the left ventricle is small in systole (208) and full in diastole (frame 244). In frame 244, the aorta is well opacified, and an area of minimal narrowing just distal to the aortic arch is faintly seen.

from right to left ventricle was observed. Thus, the diagnosis was unmistakably established by biplane cineangiocardiography. The observation of the opaque medium moving from right to left ventricle as a short, high jet might have been missed at a significantly slower exposure rate.

(*b*) *Cor triloculare:* Among three cases of single ventricle which we have studied, one was associated with transposition and pulmonic stenosis, another with normal position of the great vessels but combined valvular and infundibular stenosis, and still another with pulmonary atresia. This is an important lesion to distinguish, since with open cardiotomy the reconstruction of a ventricular septum remains a very difficult problem, and this must be considered in assessing the risk of surgery. It is possible to obtain some idea of the kind of septal remnant that is present, since in at least one case a muscular ridge between the two freely communicating portions of the ventricular chamber was visible.

5. *Miscellaneous:* (*a*) *Mitral Insufficiency.* Following right ventricular or pulmonary artery injection, the large size of the left atrium and ventricle is well defined. Just before ventricular systole, the atrium begins to expand if the mitral valve is incompetent, and the diameters of the left atrium are increased significantly between atrial systole and diastole, in spite of the large residual volume of the left atrium. This, of course, reflects the rather marked increase in overall atrial volume and contrasts with the relative lack of change in atrial volume in mitral stenosis. If the catheter can be placed directly in the left ventricle, then the regurgitant jet from left ventricle to left atrium can be sharply defined. If insufficiency is not present, the mitral valve will be seen protruding into the opacified ventricular chamber during atrial diastole, and the nonopaque blood which enters the ventricle during ventricular diastole will be visible as a negative filling defect.

Efforts to construct atrial and ventricular volume curves in mitral stenosis and insufficiency with the use of conventional angiocardiography have been undertaken in the past. These have usually been based on exposure rates of 4 to 10 per second. With 48 exposures per second, a larger number of points in each cardiac cycle can be analyzed, and more accurate measurements should be attainable. This involves the study of the still frames and their projection in a scale which duplicates the actual cardiac size. For this purpose it is desirable to have a measuring rod as an indication of the degree of distortion. In each study, therefore, a 5-cm. plastic ovoid, with lead strips at intervals of 1.0 cm. is employed as close to the midplane of the heart as is possible.

(*b*) *Ventricular Aneurysm:* A single case of ventricular aneurysm was studied in a 35-year-old man who had had two coronary occlusions one year before entry. Following left atrial opacification, the bulk of the ventricular cavity was opacified, but not the area of the aneurysm. With ventricular contraction, the aneurysm was opacified slightly, and bulged laterally. Its base was obviously wide, but failed to opacify densely until after aortic filling, when it retained the opaque material for a prolonged period of time. This suggested that blood was pooling in the region of the aneurysm, that a significant part of the ventricular output was required merely to distend the aneurysmal sac, and that this might be contributing to left ventricular inefficiency and, consequently, to the patient's symptoms. Because of this, surgery was recommended.

(*c*) *Endocardial Fibroelastosis:* In cases of endocardial fibroelastosis the passage of the opaque medium through the heart into the systemic circulation was delayed. The left atrium and left ventricle were enlarged, and the left ventricular wall thickened. In one case, gross right ventricular dilatation was also present, indicating, and presumably resulting from, involvement of the right ventricular endocardium. A striking finding was the diminished amplitude of contraction of the

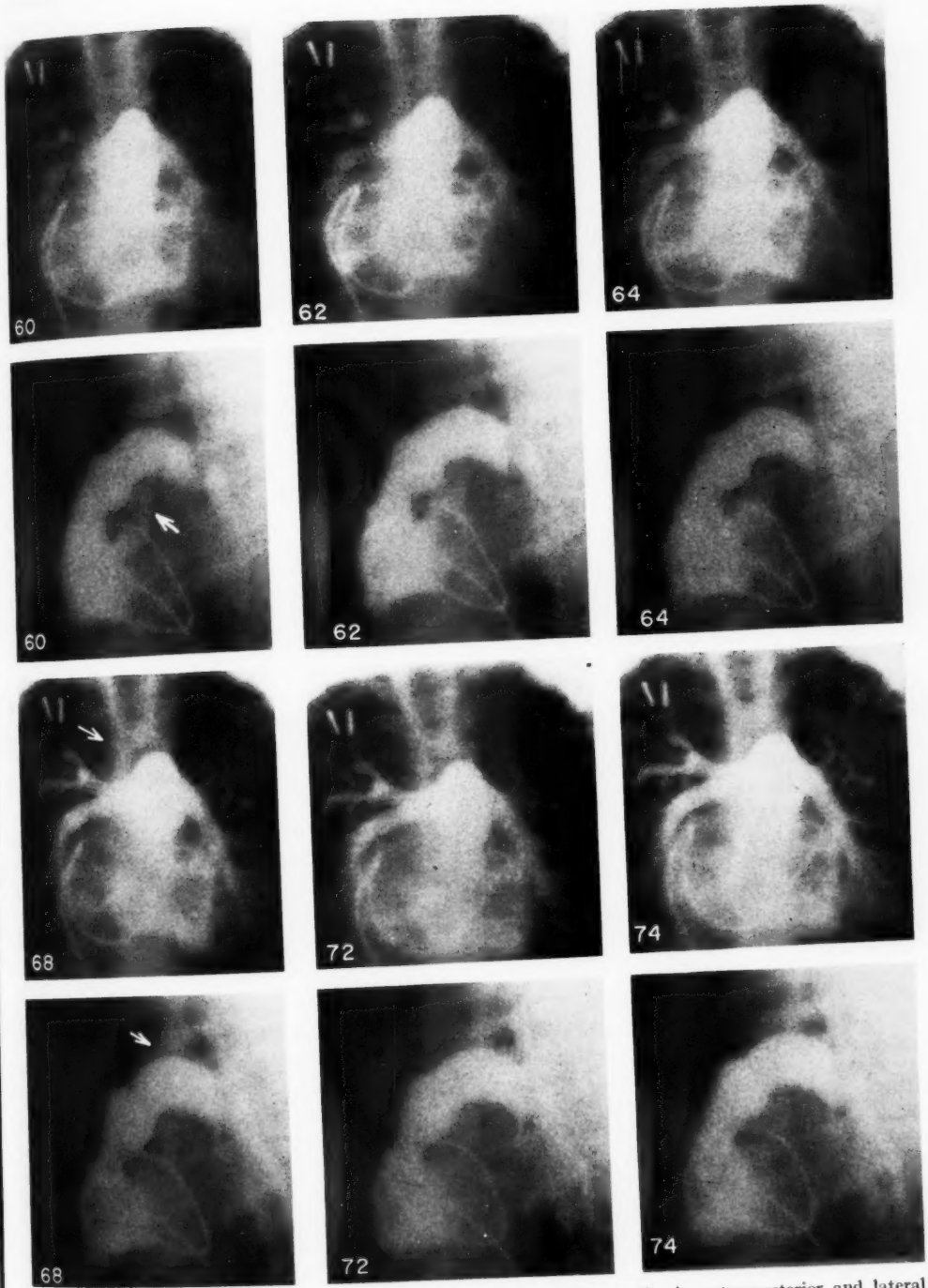

Fig. 2. The Eisenmenger complex. Biplane cineangiocardiographic studies in anteroposterior and lateral projections. In frames 60, 62, and 64, the right-to-left shunt through a ventricular septal defect is best seen in lateral projection. On frame 68, faint opacification of the aorta may be seen both in frontal and lateral projections, and this is also visible in frames 72 and 74.

left ventricle.[3] In spite of the large volume of this chamber, a relatively slight change in volume in different phases of the cardiac cycle was observed. This inability to expel left ventricular blood efficiently is almost certainly responsible for the intractable heart failure commonly associated with this disease.

(*d*) *Aortic Stenosis:* Cineangiocardiographic study of a six-week-old boy in heart failure demonstrated gross dilatation of the left ventricle, some narrowing of the aortic root with dilatation beyond, and persistent left ventricular opacification. The diagnosis of congenital aortic stenosis was made, and the child was explored under hypothermia. Fusion of the aortic cusps was found. Correction was undertaken with a dilator, and good valve motion was attained.

DISCUSSION

Relatively few reports have been published in which the usefulness of the cineangiocardiographic method as a clinical tool in heart disease has been evaluated (3, 4, 6–13). In our experience, it is difficult to separate the cine-examination from the physiologic studies which are obtained concurrently and which should be an integral part of the procedure. Nevertheless, within the limits of this symposium, it might be well briefly to review some of the advantages and disadvantages of the cinemethod.

Advantages of Cineangiocardiography

1. *The Study of Motion:* There is no substitute, in the radiologic approach to disease, for the study of moving organs in motion. In this area lies the strength of cineangiocardiography, in reproducing the *in vivo* conditions under which the heart and great vessels operate. Valve motion, the direction of shunts, ventricular and atrial changes during the heart cycle, the fixed or transient character of localized changes in the great vessels—all of these may be superbly analyzed by the cinemethod. What may be an imperceptible change on radiographs viewed individually becomes visible change when seen in motion. This explains the usefulness of cinestudies in left-to-right shunts, in which conventional angiocardiographic studies have at times proved disappointing.

2. *The Framing Rate.* Since the opaque medium usually remains in the heart and great vessels for very short periods of time, studies based on a small number of exposures during two or three cardiac cycles may not be satisfactory, because only a few points in the cycle are recorded. The ability to expose 48 or more frames in one second permits a range of from 30 or more to about 16 views (at 180 beats per minute) during each cardiac cycle. Phenomena that are momentary and maybe missed at low exposure rates are caught and fixed in the film, to be analyzed at leisure.

3. *The Field Size:* Excellent cineangiocardiograms have been obtained with the 5-inch image intensifier and a 16- or 35-mm. motion-picture camera (3, 8, 12). The 5-inch field size is best adapted to infants, but permits recording of too circumscribed an area for proper study of the adult heart and great vessels. In this respect, the 11-inch intensifier has increased the range of studies possible. This field size has proved adequate for a large variety of examinations both in children and adults, with inclusion not only of the entire cardiac silhouette, but also the pulmonary vessels and the aorta. By the same token, the 11-inch field size is somewhat disadvantageous in the study of infants, since a significant portion of the 35-mm. frame is inevitably wasted.[4]

4. *The Dynamics of the Heart in Disease:* From an investigative point of view, synchronized views of the heart at right angles to each other during cineangiocardiography permit intensive analysis of concurrent changes in three dimensions—

[3] Since this paper was prepared an additional 80 cases have been studied by biplane cineangiocardiography. In one proved case of endocardial fibroelastosis the amplitude of left vetricular contraction was not significantly diminished.

[4] The camera has a fixed focus and must record the entire area of the 11-inch intensifier screen.

height, width, and depth. This method lends itself to evaluation of ventricular volume changes better than any other technic available (5). It has the potential for clarifying the amount of reflux through insufficient valves and may even lend itself eventually to quantitation of shunts and cardiac output if adequate densitometric scanning is possible.

5. *Evaluation of the Study During Injection:* Because the intensifier screen is being photographed, and can be monitored throughout the study, the amount of information obtained by the examination can be roughly estimated immediately and, if further data are required, they can be obtained without significant delay.

6. *Teaching Value:* I have been surprised by the rude shock with which a cineangiocardiogram may be greeted by student, house officer, and senior staff alike. There is an inability to visualize the mode of action of the human heart *in vivo* which derives from exposure to it as a fixed, inert mass on the anatomy and necropsy table. As an example, the extent of excursion of the triscuspid and mitral valves in health and in disease is difficult to appreciate and seems "unusual" until observed on a number of cinestudies. The cinestrip represents an unexcelled technic for teaching normal cardiac motion, as well as for clarifying the direction of movement of blood, the relationships of blood flow to heart and lungs, and the chronology of events in the malformed heart.

Disadvantages of Cineangiocardiography

1. *Detail:* Detail is inferior to that visible on conventional large-film angiocardiography. When an individual frame is projected at life size and studied, it is clear that borders and outlines are not as discretely etched as is desirable. Furthermore, graininess can be significant and disturbing.

The effects of inferior detail are: in single frame viewing, structure identification may be complicated and uncertain; demonstrating abnormalities to referring physicians or students may be difficult; reproducing frames yields poor illustrative prints. On the other hand, a questionable finding on a single frame may be readily checked on others when 48 frames per second are obtained. Furthermore, study of the moving film obviates the lack of clarity to some degree and permits more precise identification of valves, chamber borders, and vessel outlines.

2. *Processing:* The problem of working out an adequate processing system is a considerable one. Good automatic processing units for 35-mm. film are few, and expensive. Hand processing is unwieldy and permits marked variation in time, agitation, etc. Some of the semiautomatic processing units we have seen are too time-consuming for satisfactory operation. Until recently, we have relied on hand processing in our department or commercial processing and have not been satisfied with the results. In consequence, we have undertaken to do our own automatic processing with a unit which seems stable and has good temperature control.[5] Since 16-mm. film reduction printing is an asset for general film showing, we have constructed a flexible optical reduction printer which, however, remains to be tested. The commercially available printers of high quality are too costly to justify their employment except when large quantities of film are constantly being processed.

3. *Viewing:* The viewing process is certainly more cumbersome than studying roentgenograms. A darkened projection room is required. The expense of a 35-mm. motion picture projector may be considerable. If the original negative is used repeatedly, it is almost certain to be scratched. Hence, reduction to 16-mm. film is desirable if the strip is to be studied often. Projectors available commercially permit satisfactory evaluation of 16-mm. film, and there are 35-mm. still projectors which allow review of the original 35-mm. negative without film scratching. The

[5] This unit is manufactured by Houston Fearless Corporation, Inc., of Los Angeles.

time involved in viewing cineangiocardiograms must also be considered, not only in terms of the mechanics of film presentation and threading, but also because each strip requires repeated run-throughs if a maximum of information is to be obtained. Findings are too transitory to be absorbed in a single viewing. Furthermore, when still frames are studied, review of 500 individual frames (a ten-second run) is obviously more time-consuming than the study of the 10 to 50 roentgenograms comprising a conventional angiocardiogram.

4. *Review with a Referring Physician:* As must be clearly apparent, the kind of rapid consultation with a referring physician that is possible with conventional studies is difficult with cinestrips. Perhaps the best approach to this problem is a weekly cineangiocardiographic conference in which all studies of the previous week are reviewed.

SUMMARY

Initial clinical experience with cineangiocardiographic studies employing 11-inch image intensifiers at right angles to each other has demonstrated specific areas of usefulness of the method. Some of the advantages and disadvantages of the technic in the study of heart disease have been analyzed briefly.

ACKNOWLEDGMENT: These studies were undertaken and performed with the collaboration of Dr. Frank L. Gerbode and the Department of Surgery, and Dr. Norman J. Sissman of the Department of Pediatrics, of the Stanford University School of Medicine.

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(*Pro le summario in interlingua, vider le pagina 547*)

Technical Factors in Selective Cinecardioangiography[1]

EUGENE C. KLATTE, M.D.,[2] JOHN A. CAMPBELL, M.D., and PAUL R. LURIE, M.D.

In obtaining over 300 cinecardioangiograms on 16-mm. film in the past two years, we have had an opportunity to evaluate the various technical details which may critically influence the diagnostic yield of this procedure. Most of these factors have been appreciated as the result of discovering technical errors, correction of which resulted in an important improvement in the diagnostic quality of the examination. Some materials and devices have been tested experimentally in the development of a more successful procedure.

We are utilizing both Westinghouse and Philips 5-inch image intensifiers equipped with 16-mm. motor-driven cinecameras for this work. These units have been adapted to standard fluoroscopic tables and 300-ma, 120-kv generators.

Focal Spot Size: The unsharpness factor of the film image can be slightly reduced by using a 0.3-mm. instead of a 1.0- or 2.0-mm. focal spot. This is due to the absolute gain in definition of the image itself. The improvement is particularly noticeable because the tube-table top distance is short (18 inches), and the object-screen distance is often unavoidably long (up to 10 inches), so that any unsharpness is appreciably magnified.

The extent to which the 0.3-mm. focal spot may be used for cine work is limited by the local heat capacity of the face of the anode. For focal spots of 1.0 mm. or more, the tube rating is limited by the total heat capacity of the anode. There is no reason, however, to utilize a focal spot larger than 1.0 mm.

The published tube rating of the 0.3-mm. focal spot confines its use to children. We frequently exceeded this limit by several fold, and the life of our first two tubes was limited to approximately 150 cases each, plus several hundred hours of fluoroscopy. This tube life at first seems exceedingly short, but by calculation each tube actually made over 150,000 individual exposures.

Table I: Magnification of Midplane Image in 20-cm. Patient

Target-table Distance (inches)	Per Cent Magnification	Actual Field Size on 5-inch Image Tube (Inches)
18	28	3.60
24	23	3.85
30	19	4.05
40	15	4.25

A 0.5 and 1.0-mm. focal spot combination on a high-voltage tube (Dynamax 46) appears most useful at present for cine work. This has recently been made available by the Machlett Company (1).

Image Magnification Factors: Since the field size is a critical limitation in cineradiography, the image magnification factor is important. Modern fluoroscopic tables utilize an 18-inch target-table top distance. The distance from the target to the midplane of a 20-cm. patient would be 56 cm. The distance from the midplane to the front of the image tube would be 10 cm. Actually, on a currently available 5-inch tube (Philips), the input phosphor is 5.9 cm. above the front of the image tube (2); thus the midplane-input phosphor distance would be 15.9 cm. The per cent of magnification can be calculated and is recorded in Table I for various target-table top distances. For an 18-inch target-table top distance the magnification would be 28 per cent. Thus, only 3.6 inches of the midplane structures would be recorded on a 5-inch image tube. It can be seen that,

[1] From the Departments of Radiology and Pediatrics, Indiana University Medical Center, Indianapolis, Ind. This investigation was supported in part by the James Whitcomb Riley Memorial Association and in part by the James Picker Foundation on recommendation of the Committee on Radiology, National Academy of Sciences—National Research Council. Presented as part of a Symposium on Cinefluorography in Medical Practice at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16–21, 1958.

[2] Scholar in Radiological Research of the James Picker Foundation.

as the target-table top distance is increased, the magnification is significantly decreased.

With newer design, such as the 8-inch tube manufactured by Zenith,[3] the image tube front-input phosphor distance has been decreased from 5.9 to 2.5 cm. This factor would decrease the per cent of magnification from 28 to 22 per cent with an 18-inch target-table top distance. With a 30-inch target-table top distance, the percentage of magnification would be decreased from 19 to 15 per cent. Thus, at this distance an 8-inch image tube would record a midplane field of 6.8 inches in a 20-cm. patient. For this reason, a tilt table providing a 30-inch target-table top distance is desirable, but this is not currently practical. The gain in demagnification with target-table top distances of over 30 inches may not be enough to justify the problems of table design. Another factor must be considered. The calculations in Table I were made without the interposition of a spot-film device between the patient and the image tube. Some spot-film devices remove the image tube front 10 cm. from the patient. With an 18-inch target-table top distance and a 5-inch Philips tube, the magnification would be increased from 28 to 35 per cent. It can be seen that there is a distinct advantage of mounting the image tube on the table without interposition of a spot-film device.

Input Phosphor Characteristics: There is a definite lower threshold of x-ray intensity below which the input phosphor of the image tube will not receive a sufficient number of x-ray photons to cause enough confluent excitation of the crystals of the input phosphor to produce a clear electron image from the photocathode (3). Consequently, the intensification of the scintillations produced by these individual photons gives rise to a coarse mottling and graininess, which are objectionable. With a fast lens system and film emulsion, this graininess may be observed with intensification of 500 to 1,000 times at a filming rate of 32 frames per second. Image intensification beyond this point may not be utilized to reduce radiation dose to the patient without a sacrifice of image quality. This necessitates a higher radiation dose to the patient. If, however, the radiation exposure is eliminated during the phase of film movement by means of a synchronized circuit, the total dose is reduced to a reasonable level.

Output Phosphor Characteristics: The grain size of the output phosphor is roughly equivalent to that of a high-speed radiographic intensifying screen with a relative unsharpness factor of 0.3 mm. (4). With similar screen material, the phosphor 1/2 inch in diameter (Philips) produces a brighter but grainier image than the 1-inch phosphor (Westinghouse), because the picture is being produced on only one quarter of the area. Furthermore, since the final image is reduced by the lens system to fit the 7.5-mm. height of the 16-mm. movie frame, there is greater reduction of the image from the larger than from the smaller phosphor. Consequently, the lens system carries the increased graininess of the small phosphor to the film with less reduction than the larger phosphor. Since the image-to-grain ratio of the output phosphor is only one of several factors which may limit image detail, this in itself may be relatively insignificant.

One technical requirement of importance in this area is that the image be sharply focused on the output phosphor. This is accomplished by varying the electrostatic focus of the image tube and observing the relative sharpness of the cine detail of a 32-mesh wire screen.

Lens System: The objective lens is focused on the output phosphor and projects light into the front surface of the cinecamera lens, which is focused on the film. Since this "front-to-front" lens relationship needs to be separated by a distance of several inches to allow light to be reflected by mirror optics to a viewing mirror or television vidicon, some light at the edges of the field emerging from the objective lens is not gathered by the second lens, and there may result a vignett-

[3] Rauland Tube Division, Zenith Radio Corporation of America, Chicago, Ill.

ing or loss of light at the periphery of the film image. This effect tends to be more pronounced with certain lenses and can be corrected by decreasing the separation between the two lenses or by utilizing a better quality lens combination.

The focal length of the lenses will alter the size of the film image. With the limited field size available with present-day image tubes, it is better to frame the entire image so that none of the picture will be cut off. Within these technical limitations, one should strive for the fastest lens system possible to assure lower radiation doses.

Camera: The greatest and perhaps the only advantage of 35-mm. cineradiography is that the larger film frame (18 × 24 mm.) allows better image detail because the reduction ratio of the original image is critically less than with 16-mm. filming. Because of the relative unsharpness factors inherent in the image tube and lens system, the better image detail of 35-mm. film compared to 16-mm. film is difficult to appreciate on projection. This is particularly true if 35-mm. film is optically reduced to 16-mm. size for projection. Whether or not the larger field size available with newer tube design will necessitate the use of a 35-mm. camera in order to maintain good diagnostic quality requires further clinical evaluation. Camera and film cost, film reduplication, processing, storage, projection, and film handling problems are significantly less with 16-mm. With presently available lens systems the same film emulsion requires two times more radiation with the 35-mm. than with the 16-mm. camera.

The camera should operate at 8 to 60 frames per second for study of slower and faster motion. The adaptation of magazine loading simplifies film changing but may disturb the delicate focus of the lens. This can be avoided by radiographing a fine mesh wire screen periodically to assure sharp focus.

Radiation Dose Levels: The radiation dose to the patient depends upon the following factors:

1. Filtration of primary beam.
2. Kilovolt level.
3. Image intensification factor.
4. Type of rectification, constant potential or dynapulse circuit.
5. Synchronized or nonsynchronized exposures.
6. Film emulsion speed and type of processing.
7. Filming speed in frames per second.
8. Speed of lens system.
9. Camera, 16 or 35-mm.

In comparing radiation doses with different types of cinefluorographic apparatus with different intensification tubes, one should measure the roentgen input at the phantom for the same film density at the same filming speed, with the same film, at the same kilovoltage, regardless of the milliamperage. Unless comparable film images are achieved, a difference in radiation dosage may be fallacious.

The comparative roentgen outputs for our Philips and Westinghouse cine units are shown in Table II. These units have the same type of x-ray tubes (Dynamax 46, 0.3 mm. 2.0 mm., focal spot) and 3 mm. of aluminum filter. The Philips utilizes a constant potential circuit without tube-camera synchronization, and the Westinghouse has full wave rectification with thyratron type of tube-camera synchronized exposures. The film record was made on Linagraph Shellburst film developed for five minutes in an x-ray developer. It should be remembered that the intensification gain of image tubes of the same manufacturer may vary by several hundred times, so that these dose levels are not necessarily applicable to other units of similar design.

TABLE II: COMPARABLE RADIATION DOSES OF WESTINGHOUSE AND PHILIPS CINEFLUOROGRAPHY UNITS
(0.3 mm. focal spot; 30 frames per second; 80 kv.)

Westinghouse		Philips	
5 cm.	5.6 r/m	5 cm.	0.6 r/m
10 cm.	5.6 r/m	10 cm.	1.8 r/m
15 cm.	13.0 r/m	15 cm.	4.1 r/m
20 cm.	26.0 r/m	20 cm.	13.0 r/m

One cardiographic sequence rarely exceeds six seconds in length and therefore delivers one-tenth of the dose per minute quoted in Table II. Thus, with the West-

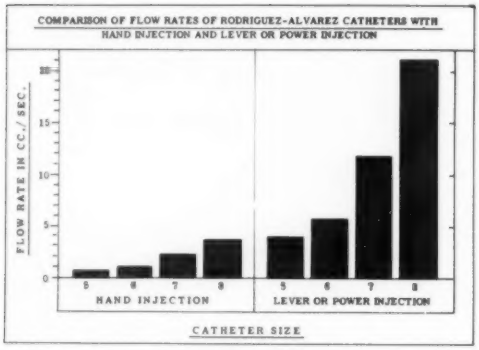

Figure 1

inghouse unit, a 15-cm. child would receive 1.3 r per sequence. This is significantly less than from the same examination performed with a rapid cassette changer.

With a fully ray-proof table with a closed Bucky slot and a leaded table top with 10-inch filming aperture, the radiation dose to the operator is less than 1.0 mr per examination.

Projection: Cine films are best interpreted with an analyzing 16-mm. projector which preferably has the following attributes: (*a*) forward and reverse motion without flicker at 1 to 24 frames per second; (*b*) continuing single frame analysis without burning of film; (*c*) 2-inch focal length projection lens; (*d*) 1,000-watt illumination and cooling capacity; (*e*) 100 to 400 foot reel capacity; (*f*) remote hand control of all projector functions. There are no 35-mm. projectors which meet these requirements. Two satisfactory 16-mm. projectors are available.

The Weinberg-Watson Kodak Analyst (5) offers good single-frame and slow-motion projection and handles film lengths up to 400 feet without any added attachments. One disadvantage of this unit lies in the fact that remote control is incomplete and both hands must be used for full operation. Although the flicker has been significantly reduced by a 5-blade shutter, it is still rather objectionable at low projection rates. The complete cost of the instrument is $795.

The Perceptoscope offers complete remote control of all projection functions by hand, at distances up to 50 feet from the unit.[4] The film transport time has been reduced to 1/140 second, so that flicker is not noticeable at rates as low as one frame per second. There is a self-rewinding device for films under 100 feet in length and such films do not need to be handled on reels. The unit has the disadvantage of requiring an extra attachment for projection of film lengths over 100 feet. The cost of this projector is $1,382.50. The 400-foot attachment adds $275 to this cost.

Injectors: The most frequent cause of unsatisfactory selective cardioangiograms is too slow injection of the opaque media. In venous angiocardiography a skilled injector with a Robb syringe and 12-gauge needle may inject up to 25 c.c. per second. With selective angiocardiography the resistance to flow is increased due to the long narrow-bore catheter. Figure 1 is a comparison of the flow rates with Rodríguez-Alvarez catheters of various sizes when 90 per cent Hypaque was injected by hand and with a power injector. It is readily apparent that with power injection the flow rates are increased almost five times; a No. 5 catheter has the same flow rate as a No. 8 catheter with hand injection.

Most of our experience has been with a lever-type injector manufactured by the Elema-Schönander corporation.[5] The flow rate with this injector is comparable to that of the Gidlund (6) injector set at 6 kg. per sq. cm. Since beyond this pressure setting there is danger of rupture of the catheter, the lever injector and power injector have approximately the same flow rates. The Gidlund power injector has the advantage that the operator may be remote from the angiocardiographic table. With film-changer technic, this is of more advantage than with cineradiography, where the exposure to the operator is negligible.

The original Taveras injector, designed

[4] Perceptual Development Laboratories, 6767 Southwest Ave., St. Louis, Mo.

[5] Manually operated injection syringe for angiocardiography, Elema-Schönander, Stockholm, Sweden.

for cerebral angiography[6] was tested and was found to have the same maximum flow rate as the Gidlund set at 4 kg./sq.cm. The Taveras unit is being redesigned by the manufacturer to increase its injection force to levels necessary for selective cardioangiography.

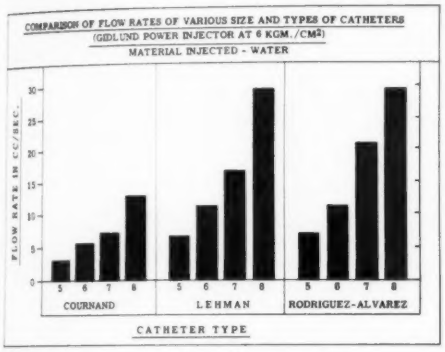

Figure 2.

Catheters: In our series selective cardioangiography as introduced by Chavez *et al.* (7) was routinely employed. It has many advantages over venous angiocardiography. The medium is injected at the point of interest so that overlying contrast-filled chambers do not obscure the anatomical or pathological details. It is introduced as a single bolus so that delayed emptying of the right heart does not obscure a left-to-right shunt. Since the contrast agent is not diluted by a large volume of blood, a smaller dose may be utilized.

The choice of the catheter is important. Most commonly utilized in cardiac catheterization are the Cournand or Goodale Lubin catheters. These have thick walls and narrow lumens and are not applicable to selective cardioangiography. The Lehman catheter has a much larger lumen-wall ratio and a much higher flow rate than the Cournand catheter. A serious disadvantage of all three of these catheters is that they have an end opening. The force of the injection would frequently cause the catheter to recoil into the right atrium. A catheter developed by Rodríguez-Alvarez (8) (available through U. S. Catheter and Instrument Company) replaces the end hole with six laterally directed openings. Recoil has not been observed with this catheter. Figure 2 demonstrates the flow rates of Cournand, Lehman, and Rodríguez-Alvarez catheters. It may be seen that the Lehman and Rodríguez-Alvarez catheters have approximately twice the flow rate of the Cournand catheter.

[6] Automatic hydraulic injector for angiography, Juan M. Taveras, Presbyterian Hospital, New York.

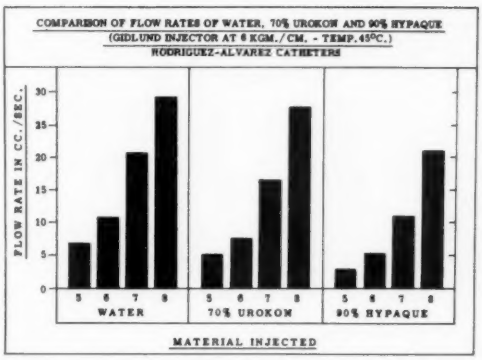

Figure 3.

Contrast Media: The two most commonly used opaque media for angiocardiography are 70 per cent Urokon and 90 per cent Hypaque. At first we utilized 70 per cent Urokon exclusively. This material is almost equivalent to water in viscosity and gives excellent contrast. Approximately eighteen months ago we began using 90 per cent Hypaque, which has the same iodine content and opacity as 70 per cent Urokon. With the use of Hypaque, a considerable decrease in systemic side reactions was observed. This medium has the disadvantage, however, that it is quite viscous. We routinely heat it to 55° C. prior to injection, but even so the viscosity is still considerably greater than that of 70 per cent Urokon. Figure 3 demonstrates the relative flow rates of water, 70 per cent Urokon, and 90 per cent Hypaque. It can be seen that the flow rate of 70 per cent Urokon is only slightly less than that of water. With 90 per cent Hypaque there is an approximately 25 per cent decrease in the rate of flow as compared to 70 per cent Urokon. In spite of this disadvantage, the marked decrease in systemic

TABLE III: FILM EMULSION CHARACTERISTICS FOR CINEFLUOROGRAPHY

Film	Speed	Grain Size	Contrast
1. Shellburst	100	Good	Excellent
2. Linagraph Ortho	100	Fair	Fair
3. Plus X	80	Excellent	Fair
4. Du Pont 931 A	150	Fair	Fair
5. Cine Flure	180	Poor	Excellent
6. Du Pont 928 A	160	Fair	Poor
7. Tri X Reversal	260	Poor	Good
8. Tri X Negative	260	Poor	Fair
9. Du Pont 930	80	Excellent	Fair
10. Du Pont 936 A	130	Excellent	Fair

reactions makes 90 per cent Hypaque the present medium of choice.

For each injection we use approximately 0.5 c.c./kg. for stenotic lesions and 0.7 c.c./kg. for large left-to-right shunts. We utilize one to four injections in various projections. The multiple small injections have caused no serious reactions in our series.

Film Emulsions: The three factors important for film emulsions in cinefluorography are speed, contrast, and grain size. Prior to image amplification, film speed was all-important because the irradiation exposure was extremely high and the fastest emulsion had to be used in order to keep the exposure below harmful levels. Since the advent of image intensified cinefluorography, it has been possible to sacrifice some film speed in order to gain other desirable qualities. It must be remembered that the published ASA ratings are for panchromatic light. The light from the output phosphor of the image tube is monochromatic in the green spectrum. These ASA ratings are not applicable in determining the speed of film for cinefluorography. We have tested 10 currently available emulsions. The exposure necessary to give a net film density of 0.85 was measured. An arbitrary rating of 100 was given to Linagraph Shellburst. All emulsions were developed in x-ray developer at 68° F. for five minutes.

Contrast is the difference in density of various parts of the film. X-ray film has a high contrast. A film approaching x-ray film in contrast is desirable.

The grain size is another factor of importance. The image of a 16-mm. movie frame is 7.5 mm. If this is projected to a diameter of 1 meter there is an enlargement of over 1,000 times. The grain in the film becomes apparent and may be objectionable.

Table III compares 10 film emulsions which have been utilized in cinefluorography. Most of our clinical experience has been with Eastman Kodak Linagraph Shellburst film. This film has only moderate speed; however, the grain size is not objectionable and the contrast is unexcelled. Du Pont 931 A and Du Pont 936 A show promise. They are somewhat faster than Shellburst, but their contrast is only fair. Cine Flure, a fairly new film, has good speed and excellent contrast. The grain is rather coarse and may be objectionable. Tri-X reversal film is even faster than Cine Flure and offers good contrast. The grain size is equivalent to Cine Flure.

In summary, we feel the best cinefluorogram is obtained with Linagraph Shellburst film. The disadvantage of this film is that it has only moderate speed. If the radiation dose with this emulsion is objectionable, Du Pont 931 A or 936 A may be used. These are faster than Shellburst and have only moderate grain. If ultimate speed is indicated Cine Flure and Tri-X reversal appear to be the films of choice. Both have good contrast, but the grain size may be objectionable.

Processing: The choice of developing solution is important. A good developer should enhance the contrast and bring out the ultimate speed of the emulsion. X-ray developer is ideally suited for this purpose, doubling the film speed as compared with medium grain developers. Contrast is also enhanced.

We have successfully processed 200 feet of Shellburst film in an Eastman Kodak X-Omat by attaching the end of the film to an x-ray film. If, following further studies, the X-Omat proves to be a practical means of processing cine film, one of the real problems of the radiologist will be greatly simplified.

Positioning: It must be realized that the radiologist is a member of the cardiac team. At Indiana University, cinecardioangiography is almost routinely performed at the completion of cardiac catheterization. The case is discussed with the cardiologist, and the information from catheterization is utilized to determine the positioning of the patient and the site and quantity of injection. The ease of the examination cannot be overemphasized. Rarely is more than twenty minutes of the radiologist's time consumed. A great advantage of cinecardioangiography is that the cardioangiogram may be monitored on the periscopic mirror during the filming procedure. This assures that a satisfactory injection of contrast media has been made, and governs what further studies should be performed best to determine the abnormal anatomy and physiology.

By utilizing the saphenous approach, the left heart may be entered through a patent foramen ovale in approximately one-third of pediatric patients. The left heart is an ideal site of injection to demonstrate left to right shunts or aortic lesions. If the left heart cannot be entered, the pulmonary artery is the next injection site of choice. To demonstrate pulmonary stenosis the injection is made in the apex of the right ventricle.

The interatrial septum is best demonstrated in a 30° left anterior oblique view. The ventricular septum and aortic arch are best demonstrated by a 70° left anterior oblique. The pulmonary outflow tract and pulmonary valve are well visualized in a 45° right anterior oblique. A patent ductus is frequently best seen in the postero-anterior projection. Table IV summarizes the positioning and site of injection frequently used for the more common types of congenital heart lesion.

TABLE IV: POSITIONS AND INJECTION SITES FOR SELECTIVE CARDIOANGIOGRAPHY

Condition	Position	Site of Injection in Order of Choice
Interatrial septal defect	30° LAO	1. Left atrium 2. Pulmonary artery
Interventricular septal defect	70° LAO	1. Left ventricle 2. Left atrium 3. Pulmonary artery
Patent ductus	70° LAO PA	1. Left ventricle 2. Left atrium 3. Pulmonary artery
Pulmonary stenosis	45° RAO	1. Right ventricle
Coarctation	70° LAO PA	1. Aorta 2. Left ventricle 3. Left atrium 4. Pulmonary artery
Tetralogy of Fallot	45° RAO 70° LAO	1. Right ventricle 1. Left or right ventricle

SUMMARY

The technical factors important for obtaining high-quality cinecardioangiograms have been discussed.

1. An x-ray tube with a 0.3 and 1.0-mm. focal spot combination currently offers the best image detail within a safe operating range for cine work. (See appended Note, p. 546)

2. The maximum field recorded on the film is obtained with the longest target-object distance and the shortest object-input phosphor distance possible within the limitations of practicality.

3. Image intensification itself can be used only to decrease radiation dose to a certain level, beyond which film detail suffers significantly.

4. The lens system should be fast, free of vignetting, and of high quality.

5. Cinecardioangiograms of diagnostic yield equal to that obtained with 35-mm. film can be readily produced on 16-mm. films, with a significant decrease in radiation dose, cost, and handling problems.

6. Cinecardioangiograms in three projections of greater diagnostic yield than those obtained with rapid cassette changers can be produced in children with a total radiation skin dose of 3 to 7 r.

7. A high quality 16-mm. analyzing projector is necessary to appreciate fully the advantages of the cine method in cardioangiography.

8. High-quality selective cinecardioangiography depends significantly on the proper catheter, contrast medium, injector, and positioning of patient.

9. The highest quality cinecardioangiograms were obtained with Linagraph Shell-

burst film processed for five minutes in regular x-ray developer at 68° F.

NOTE: In considering the proper focal spot combination to select in the Dynamax 40 for cine work, the rating charts show that the 1.0-, 1.5-, and 2.0-mm. focal spot sizes all are limited in rating only in respect to the total anode heat storage (110,000 heat storage units) in the range of voltage and current usually employed in these cine technics, namely up to 100 pkv and 50 ma. (The target or anode heat storage capacity becomes the limitation when the pkv-ma factors used have permissible time limits in excess of the maximum time shown on the rating chart.) This means that film runs equal to the product of pkv × ma × exposure time × frames per second divided into 110,000 heat storage units (Dynamax 40) will give the time in seconds of the maximum film run permissible.

In the case of exposures greater than those mentioned above, or of smaller focal spots than 1.0 mm., the pkv-ma factors will have maximum permissible exposure time which is determinable from the rating chart. The total heat storage units calculated from this maximum allowable single exposure then become the limitation as to target loading due to skin temperature. For instance, if it is desired to make exposures of 125 pkv at 50 ma and 1/60 second at the rate of 30 exposures per second, film runs of up to 26 seconds would be permissible with a 1.0-mm. focal spot. (125 pkv × 50 ma × 13 seconds (from rating chart for 1.0-mm. focal spot) equals 81,250 heat storage units allowable; 125 pkv × 50 ma × 1/60 second × 30 exposures per second equals 3,120 heat storage units per second. Therefore, 81,250 divided by 3,120 equals 26 seconds or the permissible total film run time.)

The ratings that apply to a 0.3-mm. focal spot must be considered in the same manner. Reference to the 0.3-mm. focal spot rating chart for this tube type shows, for instance, that the maximum individual exposure at 90 pkv and 15 ma is approximately 17 seconds. The product of these factors is approximately 23,000 heat storage units. Again, at a 30 per second frame rate and 1/60 second exposures almost 40 seconds of film run would be permissible (23,000 divided by 90 pkv × 15 ma × 1/60 second × 30 frames per second equals approximately 40 seconds).

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SUMMARIO IN INTERLINGUA

Factores Technic in Cinecardioangiographia Selective

Es discutite le factores technic que es importante pro le obtention de cinecardioangiogrammas de alte qualitate.

Un tubo a radios X con un combination de spot focal de 0,3 e 1,0 mm offere currentemente le melior detalios de imagine intra salve limites de servicio in labores cineradiographic. Le campo maximal registrate in le pellicula es obtenite per medio del maximo de distantia inter le pecia de concentration e le objecto e le minimo de distantia inter le objecto e le phosphoro de entrata, intra le limites del possibilitates practic.

Intensification del imagine per se pote esser usate solmente pro reducer le nivello del dosage de radiation usque a un limite in ultra del qual le imagine suffre significativemente in claritate de detalio.

Le systema de lentes deberea esser rapide, libere de formation de vignettes, e de alte qualitate.

Cinecardioangiogrammas de rendimento diagnostic equal a illo obtenibile per le uso de pelliculas de 35 mm es obtenibile sin difficultate per le uso de pelliculas de 16 mm, con le resultato de un reduction significative in dosage de radiation, costos, e problemas de manipulation.

Cinecardioangiogrammas in tres projec-

tiones de un rendimento diagnostic superior a illo obtenibile con le uso de rapide excambiatores de cassetta pote esser obtenite in patientes pediatric con un total dosage de radiation al pelle de inter 3 e 7 r.

Un projector analysatori de 16 mm de alte qualitate es necessari pro le realisation complete del avantages inherente in le methodo cinecardioangiographic.

Cinecardioangiographia selective de alte qualitate depende significativemente del selection correcte del catheter, del substantia de contrasto, del injector, e del position del patiente.

Le cinecardioangiogrammas del plus alte qualitate esseva obtenite con pelliculas Linagraph Shellburst, tractate durante cinque minutas in un normal banio revelatori de roentgenographia a un temperatura de 68 F.

SUMMARIO IN INTERLINGUA

Cineangiocardiographia Biplan: Observationes Clinic Preliminar

(Pagina 531)

Le experientia clinic initial in studios cineradiographic empleante intensificatores de imagine de 11 pollices disponite in relation rectangular le un al altere ha demonstrate que le methodo ha specific areas de utilitate. Su uso in 46 patientes con un grande varietate de anormalitates congenite es reportate. Ab le puncto de vista exclusivemente diagnostic, practicamente omne le studios esseva satisfacente. Le grande avantage del methodo es que illo reproduce le motion del corde e monstra le conditiones sub le quales le corde e le grande vasos functiona in vivo. Le rapide sequentia del expositiones (48 o plus per secunda) permitte obtener usque a 30 vistas pro omne cyclo cardiac, durante que le intensificator de 11 pollices rende possibile le inclusion de non solmente le silhouette cardiac sed etiam illo del vasos pulmonar e del aorta. Synchronisate vistas de interrelation rectangular permitte un analyse intense de alterationes simultanee in tres dimensiones.

Disavantages del methodo es le inferioritate del detalios de visualisation in comparation con angiocardiogrammas conventional a grande pelliculas, problemas connectite con le technicas del processage e del visualisation, e le difficultate de entrar rapidemente in consultation con le medico individual qui ha recommendate le studio.

Cinefluorography Employing Split-Image Television Type Image Amplifiers

PAUL C. HODGES, M.D., and ROBERT D. MOSELEY, JR., M.D.

IN SEPTEMBER 1955 Russell Morgan read (1), and in January 1956 published (2) a paper concerning the history and theory of image amplification. He dealt particularly with his own system that employs an RCA Image Orthicon but mentioned research that was in progress on television type amplifiers that are directly sensitive to x-rays without the necessity of first converting them into visible light. The x-ray image amplifier developed recently for General Electric by their Mr. John E. Jacobs is an instrument of this latter type. This report will describe its construction and operation and point out certain important differences between it and the amplifiers of Westinghouse, Philips, Morgan, and Moon. Preliminary cineradiographic results using the General Electric amplifiers will be presented.

The Westinghouse (3) and Philips (4) amplifiers (Figs. 1 and 2) have been shown repeatedly at radiological meetings in recent years, are available commercially, and have enjoyed some clinical use in Europe and the United States. They are so similar in construction and operation that a description of one serves for both.

An x-ray beam, having passed through the part that is being examined and the glass wall of the tube, falls on a cathode "sandwich" consisting of a thin, spherically curved disk of radiolucent material (such as aluminum or magnesium) coated with a fluorescent salt (such as activated zinc cadmium sulfide) surfaced with a photoelectric layer (such as activated cesium oxide). The x-ray quanta are converted into photons of visible light by the fluoroscopic screen, and the light causes electrons to be emitted by the surface layer of photoelectric material. These electrons are focused, accelerated, and delivered to a small anode that is coated with a phosphor (such as activated zinc cadmium sulfide), where they are converted back into a visible image many times brighter than the original.

Such amplifiers are simple to construct and operate and could be produced cheaply if volume sales could be attained, but they have several faults, including the need for three conversions from one type of energy to another, with considerable loss at each conversion.

1. An invisible x-ray image is converted into a visible light image
2. This visible light image is converted into an invisible electron image
3. The invisible electron image is converted back into a visible light image

Moon's method, which employs a scanning x-ray tube (Figs. 3 and 4), constitutes an entirely different approach to the problem (5, 6). A sharply focused, high-energy, electron beam scans a water-cooled tungsten target, producing x-rays at each of its myraid points of impingement. A tiny beam of these x-rays emerging from a pinhole in a lead baffle sweeps through space in synchronism with the scanning electron beam and falls on a large, dense, "water-clear" crystal of calcium fluoride, which absorbs it almost completely and converts it into light. If the object that is to be examined is interposed in the path of this beam, the amount of light generated in the crystal will rise and fall, depending on the density of the various parts of the object that is being scanned. An end-window phototube in contact with the crystal converts the light into an amplified electrical

[1] From The University of Chicago, Chicago, Ill. P. C. H., Professor Emeritus of Radiology; R. D. M., Professor and Chairman, Department of Radiology. Presented as part of a Symposium on Cinefluorography in Medical Practice at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16–21, 1958.

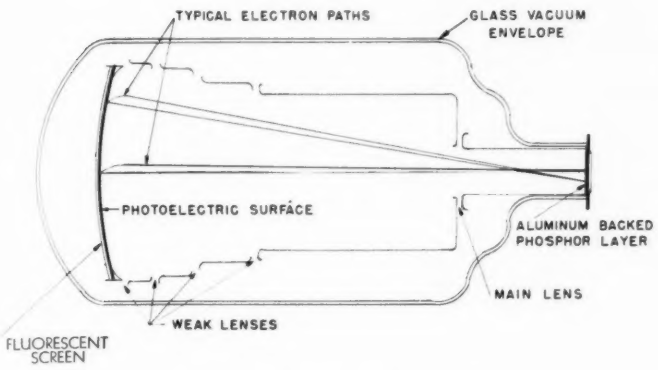

Fig. 1. Westinghouse image amplifier.

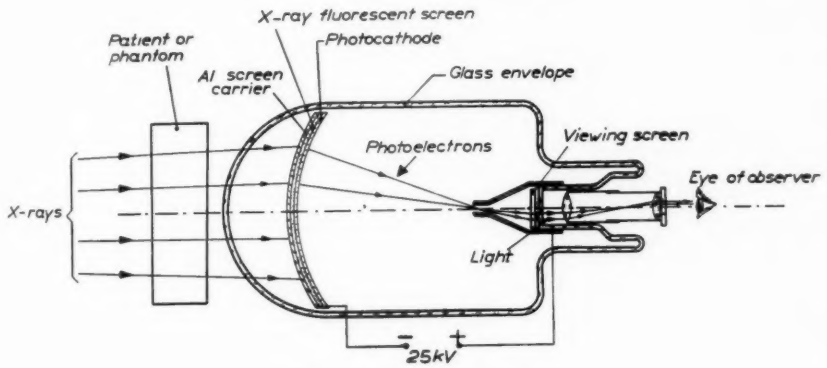

Fig. 2. Philips image amplifier.

signal, which is fed to the circuits of one or more television image tubes in which the sweep of the scanning electron beam is synchronized with the sweep of the beam in the scanning x-ray tube.

The most serious obstacle that remains to be overcome in the perfection and commercial production of Moon's amplifier is the fact that his scanning tube must produce enormous quantities of radiation at the surface of the target in order to project a minute and feeble beam through the pinhole. All x-ray tubes are wasteful of electrical energy, their useful beams constituting only a fraction of the total radiation they produce, but in Moon's tube this wastage is and must be enormous. As a result, a large and powerful high-voltage generator must be employed, the design of the cathode gun is critical, and the dissipation of heat from the target requires forced water cooling. These facts in turn require that the tube be rather large and call for the expenditure of much money and engineering skill before development can be carried beyond the laboratory stage of tubes operated on exhaust pumps to the commercial stage of tubes that are sealed off, shock-proofed, and ray-proofed as they must be for clinical use. The great advantage in Moon's method, in a sense, is a reciprocal of its chief disadvantage. The enormous wastage of x-ray quanta within the x-ray tube makes it difficult to provide an emergent scanning beam possessing an adequate number of x-ray quanta, but when this feeble beam has been produced and has passed through the part that is being examined, its quanta are utilized

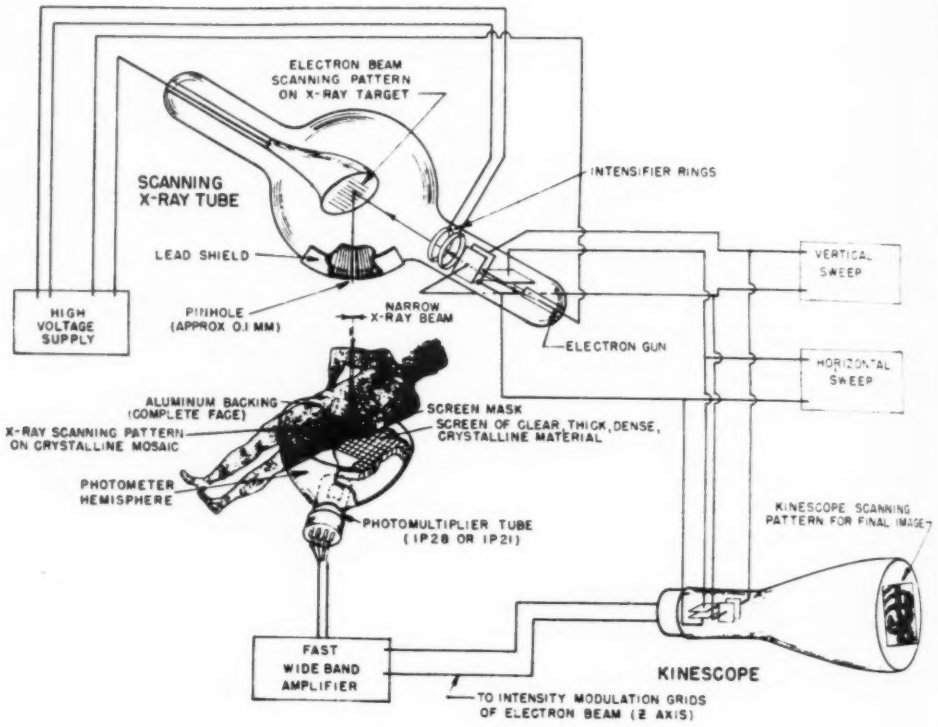

Fig. 3. Moon's system of image amplification.

almost completely. This means that human and other biological tissues examined with Moon's amplifier, as well as the radiologists who do the examinations, receive minimum x-ray doses for a given brilliance of image.

For the time being, there is no prospect of commercial development of Moon's system, but the time may well come when its unique advantage of minimum biological effect may justify such development, difficult and costly though it may be.

Morgan's image amplifier is now available commercially through the Bendix Corporation and has been described by Morgan in numerous publications, including the one referred to above (1). In addition, we are indebted to him for a copy of the operating manual used in his laboratory, for personal communications, and for the sketch of the Image Orthicon which is reproduced here as Figure 5. The Morgan image amplifier is, in effect, an unusually sensitive television camera which views an image on a fluoroscopic screen, converts it into an amplified signal, and feeds that signal to the circuits of one or more television picture tubes. It consists of two parts—a camera tube and electronic circuits for operating that tube, amplifying its signal and operating the picture tubes. The electron circuits, which were developed in Morgan's laboratory at Johns Hopkins University, not only provide an unusual degree of signal amplification but also include circuits to reduce linear and granular patterns in the television image and to synchronize that image with a motion picture camera.

The Image Orthicon (Fig. 5) operates as follows: An x-ray beam produces a visible image on a fluoroscopic screen and a fast camera lens (Eastman Kodak Ektar S-120 f/0.75 plus a 2-inch diameter field flattener) focuses this image onto a photocathode at the end of the image section of

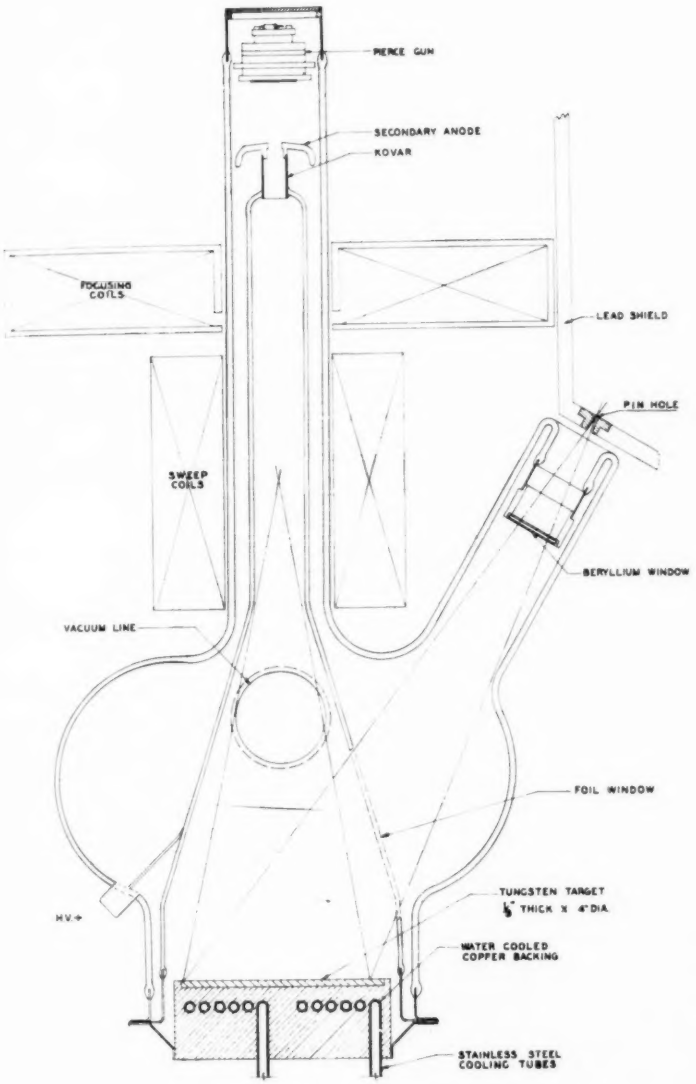

Fig. 4. Moon's scanning x-ray tube.

the Orthicon. Here the light image is converted into an electron image, which is focused and accelerated toward a thin glass target at the other end of the image section. As each of the high-speed electrons strikes the glass target, it causes the emission of approximately two secondary electrons, which are driven to the target screen and conducted away by it. The glass target thus acquires an image of the object, this time in the form of positive charges. In the scanning section of the tube, a low-voltage scanning electron beam, emitted by the cathode and accelerated by a positive charge in the electron gun, sweeps the back of the glass target, delivering electrons to it until the charge on the target changes from positive to a degree of negativity equal to that of the scanning beam. At this point the

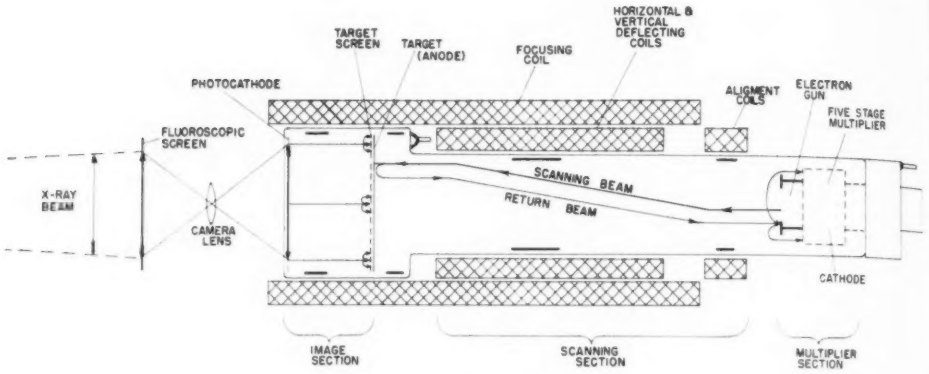

Fig. 5. Image Orthicon.

target repels electrons so that, instead of striking it, they turn back toward the highly positive electron gun which constitutes the first dynode of a five-stage amplifier. For each returning electron which strikes dynode 1, approximately four are delivered to dynode 2, eight to dynode 3, etc. At those points of high positive charge on the glass target (corresponding to bright points on the fluoroscopic image) comparatively few electrons are returned to dynode 1 of the amplifier; in other words, the television signal is weak. Where the positive charge on the target is low (corresponding to dark points on the fluoroscopic image), many electrons are returned to the amplifier section or, in other words, the signal current is large.

Morgan's amplifier is effective and convenient to use and the availability of multiple viewing tubes, including a monitor tube equipped with a motion picture camera, constitutes an important advantage. Amplification is accomplished:

1. In the image section where energy is added to the electron beam
2. In the five-stage amplifier, which is an integral part of the Orthicon
3. In the external signal amplifier

The apparatus is expensive to build and may require expert and perhaps expensive servicing, but it is important to remember that it has been in actual clinical use for several years, whereas the Vidicon type of amplifier, presently to be described, has only recently been applied clinically. Morgan's system involves the following losses of energy:

1. The conversion of x-ray quanta to light in the fluoroscopic screen
2. The conversion of light to electrons in the photocathode
3. Losses in the Ektar lens and the lens flattener

The General Electric image amplifier employs a tube similar to the commercial Vidicon which is used in some television cameras (7, 8). This tube, which the manufacturer has called X-icon, is simpler than the tubes of Westinghouse and Philips and, unlike them, allows almost any desired amplification of image brilliance plus the advantage of multiple viewing tubes, including one for motion picture monitoring. The X-icon is vastly simpler than the Image Orthicon and requires only simple and relatively inexpensive electronic circuits for the amplification of its signal.

Within the glass envelope of the X-icon there are only three parts (Fig. 6): an anode plate, an anode screen grid, and an electron gun assembly which serves as the cathode and includes the plates for vertical and horizontal electrostatic deflection of the scanning beam. The anode plate is a disk of thin aluminum sheet, slightly more than 7 inches in diameter, onto which there has been evaporated a layer of lead oxide approximately 0.15

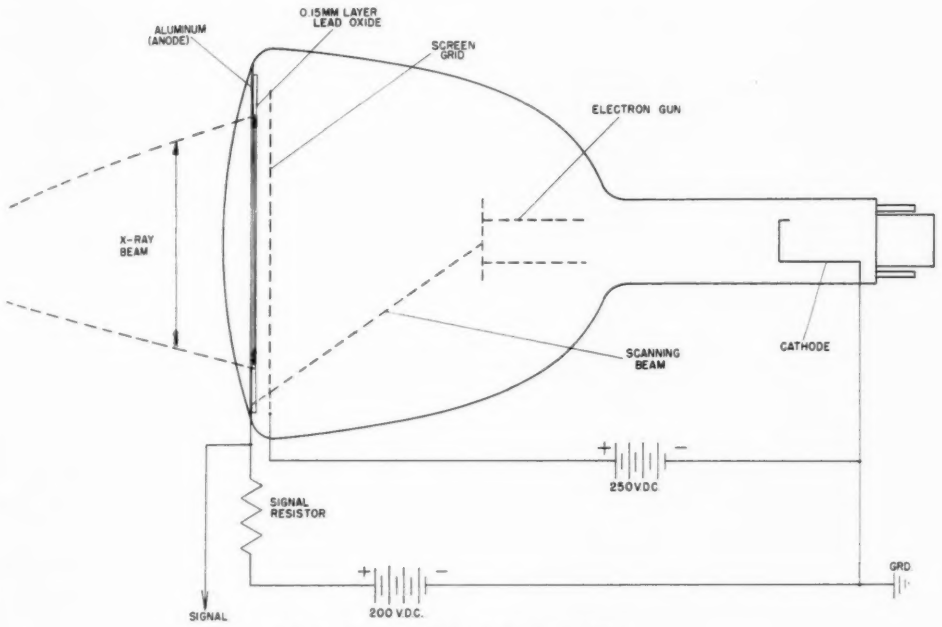

Fig. 6. General Electric image amplifier.

mm. thick. The anode screen grid is a 7-inch disk of fine wire mesh mounted close to the oxide coating of the anode, and the electron gun assembly is mounted in the stem of the tube.

Like the selenium that is used in xerography or the antimony trisulfide of the Vidicon, the lead oxide of the X-icon has high resistance when it is in the dark and becomes a semiconductor when it is exposed to light or to x-ray.

Power packs maintain the screen grid at +250 volts and the anode at +200 volts, relative to the cathode. X-rays, having passed through the object that is being examined, continue through the thin glass window of the X-icon, through the aluminum disk of its anode, and finally into the lead oxide coating, where they are partially absorbed. At bright points in the invisible x-ray image, the oxide becomes a conductor and at dark points remains a good insulator.

The cathode beam, passing through the interstices of the screen grid, sweeps the face of the target, charging the surface of the oxide to ground potential, after which the remaining electrons in the beam are returned to the screen grid. The scanning electron beam has a circular cross section 0.25 mm. in diameter and sweeps the lead oxide coating of the target at uniform speed. A given point on the target is bombarded by electrons for approximately 12/10,000,000 seconds (1.2×10^{-7}) at each sweep, and approximately 3/100 seconds (3×10^{-2}) elapse before that point is swept again. Explanation is facilitated if one thinks of the lead oxide coating not as a continuous sheet but as rows of disk-shaped picture elements, each 0.15 mm. thick and 0.25 mm. in diameter, and if he assumes that the cathode beam plays on each picture element for 1.2×10^{-7} seconds and then, without lapse of time, moves on to the next element, covering all of them and returning to the first in 3×10^{-2} seconds.

Each picture element constitutes a minute condenser in which the aluminum sheet forms one plate and the surface of the lead oxide the other, while the lead oxide between the surface and the aluminum is the dielectric. During the brief

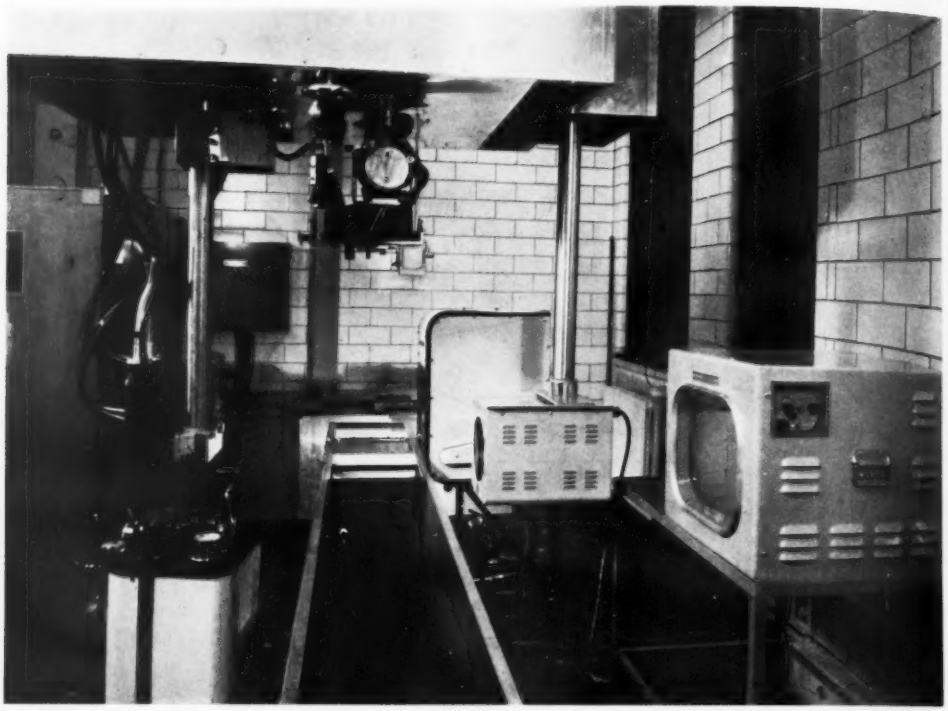

Fig. 7. Angiographic laboratory.

period (1.2×10^{-7} seconds) that the scanning beam is in contact with the surface of the lead oxide of a particular picture element, a circuit is established from ground, over the cathode and the electrons in the beam to the surface of the lead oxide, and from the aluminum plate of the anode through a signal resistor to the +200 volt side of the D.C. power pack. While this circuit is maintained, electrons flow onto the surface of the lead oxide until it reaches ground potential and a like number of electrons are driven from the aluminum plate, through the signal resistor to the power pack. If the picture element in question corresponds to a portion of the object so radiopaque as to absorb all of the incident x-ray, the dielectric of this element remains intact and no charge is lost in the relatively long period (3×10^{-2} seconds) between scans. At the next scan, therefore, the lead oxide of this element rejects electrons offered by the scanning beam; no flow of electrons occurs over the signal resistor; there is no IR drop; no signal and no bright spot on the picture tube. When the picture element corresponds to a radiolucent portion of the subject, there is heavy irradiation of the dielectric between scans and much of the charge is lost. At the next scan, therefore, the surface of the lead oxide accepts many electrons from the beam, many electrons flow from the aluminum plate through the signal resistor, producing a large IR drop, a large signal, and a bright spot on the picture tube.

In the language of television engineers, a system such as this is said to have great ability to store "information" between scans and deliver that information during the brief instant of scanning. If the signal depended merely on the number of x-ray quanta received by the picture element during the 1.2×10^{-7} seconds of actual scanning, there would be no storage of information and the picture would be of poor quality. As a matter of fact, the

system stores all of the x-ray quanta received by the picture element in the relatively enormously long period between scans (3×10^{-2} seconds), and this large storage factor makes for a picture of good quality.

The diameter of the scanning beam (0.25 cm.) determines the resolving power of the system or, in other words, its ability to record detail.

Fig. 8. Special control stands for cineradiography and angiography.

We have recently completed the permanent installation of two X-icon image intensifiers in connection with our angiographic laboratory (Fig. 7). The frontal camera is rigidly attached underneath the sliding table top and faces, at a 40-inch distance, the frontal x-ray tube (Dynamax 46). The lateral camera and lateral x-ray tube are attached to a specially constructed overhead support which allows motion of both of these elements together in a vertical direction along the axis of the table and across the axis of the table.

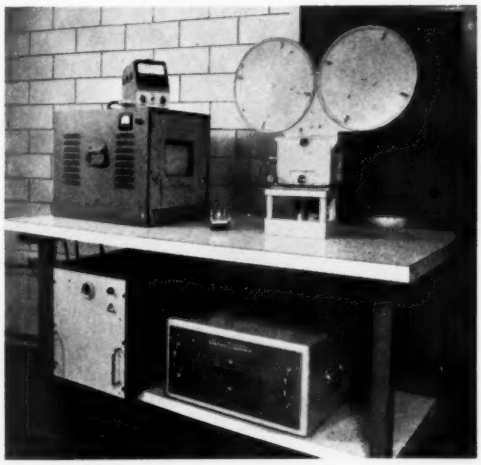

Fig. 9. Remote monitor, biplane screen unit, photoelectric densitometer, and motion picture camera.

The 40-inch target-film distance is maintained for any of these motions and the x-ray tube remains continuously in line with the camera.

A biplane Schönander film-changer is located so that the sliding table top may be used to position the patient either in relation to the image intensifier cineradiographic apparatus or over the biplane film-changers. Special tubes have been constructed for us by the Eureka Corporation; sequential films made by exposures from alternate inserts are stereoscopic. These tubes and the x-ray tubes for the cineradiographic apparatus are all operated from special transformers and control stands constructed for us by the Mattern Division of Land-Air, Inc. These control stands are illustrated in Figure 8. The details of their operation will be the subject of another report.

Viewing of the images produced on the image intensifier tubes is accomplished on two monitors—one adjacent to the fluoroscopic apparatus and one remote monitor for motion picture recording (Fig. 9). Incorporated into the circuit is an electronic circuit which allows the simultaneous display of both the frontal and the lateral image on each kinescope tube. Recording is accomplished by means of a modified Auricon camera synchronized

Fig. 10. Postmortem dog heart-lung preparation showing catheter passing through area of congenital weakness in aortic wall.

with the television screen. The light intensity balance of the split screen and the overall illumination of the kinescope screen are controlled by the use of a Densichron photoelectric densitometer. We are currently using Eastman television recording film no. 7374 and are developing our films in the Fairchild Medi-Matic 16-mm. Processor, using a phenidone developer. Developer temperature is 90° and the film is advanced at 1 or 2 feet per minute.

Most of our work has, so far, been done in experimental animals. Figure 10 is the heart-lung preparation from an autopsy of one of these. The aorta was catheterized by percutaneous femoral puncture and the catheter tip was placed in what appeared to be the ascending aorta. Actually the catheter has passed through a congenital weakness in the wall of the ascending aorta and had entered the pericardial sac. In another animal, injection was made through the jugular vein, following a surgical anastomosis of the superior vena cava with the pulmonary artery.

SUMMARY

We have discussed the principle of the biplane split- image television type image amplifier cineradiographic system and have illustrated our present installation of these devices. Preliminary cineradiographic results have been mentioned.

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SUMMARIO IN INTERLINGUA

Cinefluorographia, Utilisante Amplificatores de Imagine del Typo Usual in Television a Imagine Bifisse

In le apparato recentemente installate per le autores, duo amplificatores de imagine del typo usual in television (X-icon de GE) es empleate pro energisar le duo medietates de un receptor de television a ecran findite, providente simultaneemente fluoroscopia biplan e cinefluorographia. Le construction e le actuation e detalios del connexiones e del installationes del amplificatores de imagine e del associate tubos e generatores es describite. Pro objectivos de comparation, etiam le amplificatores Westinghouse, Philips, Morgan, e Moon es describite. Le presente systema differe ab le alteres in tanto que le amplificatores es directemente sensibile a radios X, sin le necessitate de primo converter los in lumine visibile.

Cinefluorographic Study of Pharyngeal Function Related to Speech[1]

JOHN A. KIRKPATRICK, M.D., and RICHARD W. OLMSTED, M.D.

CINEFLUOROGRAPHY, utilizing an image intensifier and a camera that permits the simultaneous optical recording of sound, offers a technic for the visualization of the movements of the palate, tongue, and pharyngeal soft tissues during speech. The record obtained is a permanent one with which subsequent examinations may be compared. The technic is not unique. Cooper in 1955 reported on the use of cinefluorography in the fields of plastic surgery, dentistry, and speech. In his initial study, sound was recorded on a magnetic tape during cinefluorography and subsequently added to the film record; later, he employed optical recording of sound. Both optical and magnetic recording result in sound synchronous with the motions of the oral and pharyngeal structures. Optical recording is less complicated in that the sound track is exposed directly on the film and developed with the pictures.

The apparatus in use at St. Christopher's Hospital for Children (Philadelphia) is illustrated in Figure 1. There are three basic units: a conventional fluoroscopic tube, table, and tower; an image intensifier of the electron optical type manufactured by the North American Philips Co., Inc., a 16-mm. "sound on film" camera (Auricon Cine-Voice II). The camera is equipped with a 25-mm. f.95 lens focused at infinity. With the fluoroscopic table in the upright position, the patient sits on the foot rest so that the pharynx is viewed in the lateral projection. A microphone is held 12 to 18 inches from the patient. Motion pictures are exposed at the rate of 24 frames per second as the patient speaks. Another exposure is made as the patient swallows a barium and water mixture to demonstrate regurgitation into the nasal cavity. It has not been necessary to use contrast material for visualization of the intra-oral and pharyngeal structures; the air around them is sufficient. The patient is exposed to the x-ray beam (a circle 5 inches in diameter) for forty-five to sixty seconds. This produces 30 to 35 feet of exposed film with 1,000 to 1,500 individual frames available for study. The amplifier for the camera is so constructed that sound-track exposure is calibrated and hence is reproducible at subsequent examinations. Tone may be controlled and, when children are being examined, it is helpful to increase the volume of the low frequencies.

There is a need for increased knowledge of the motor activities of the lips, tongue, mandible, soft palate, and pharyngeal soft tissues during speech and of their relation to the production of speech in both the normal and abnormal oral cavity and pharynx. As Calnan has observed, the physician is at a disadvantage in the examination of patients with abnormalities of the palate, pharynx, or abnormal speech. It is difficult to evaluate the effect of cleft, short, or paralyzed palates on sound production, as speech occurs with the mouth partially open and the observation of tongue and pharyngeal movements is limited or impossible and examination by means of a tongue depressor results in a distortion of anatomy and physiology.

Lateral radiography of the pharynx has made a significant contribution to the evaluation of oral and pharyngeal soft tissues. One may observe the length of the soft palate and gain an estimate of its function by exposing a radiograph as the patient emits a sustained sound requiring velopharyngeal closure. The size and shape of the pharynx and the amount and distribution of lymphoid tissue may be seen. Most of the information obtained, however, is ana-

[1] From St. Christopher's Hospital for Children, Philadelphia, Penna. Presented as part of a Symposium on Cinefluorography in Medical Practice at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16–21, 1958.

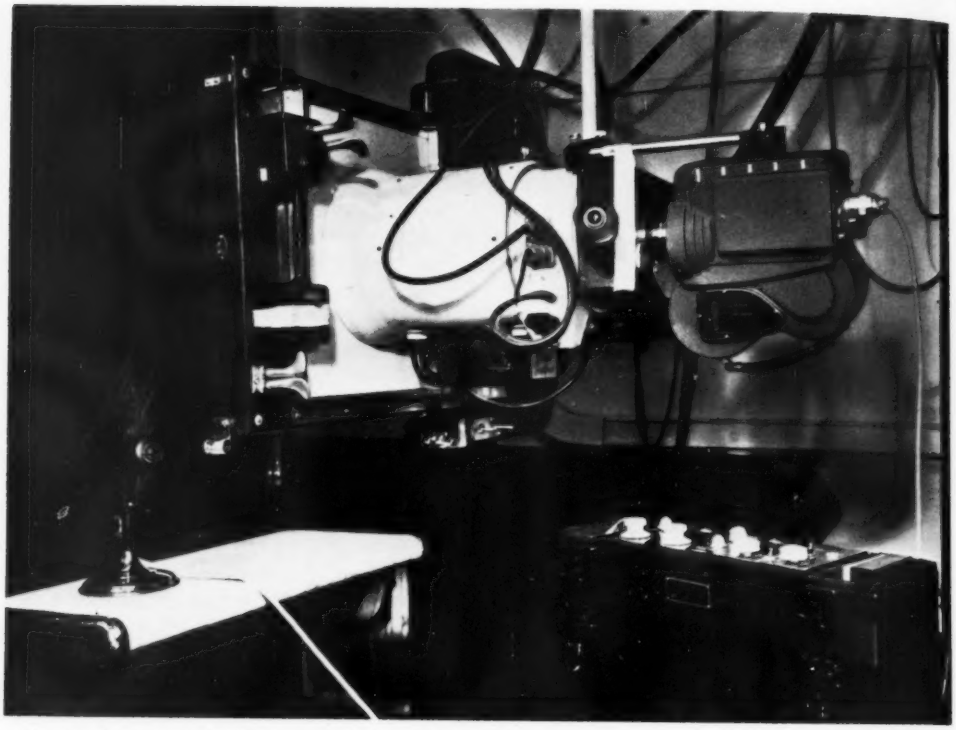

Fig. 1. Apparatus for cinefluorography and the simultaneous optical recording of sound. With the fluoroscopic table in the vertical position, the patient sits on the foot rest. The pharynx is viewed in the lateral projection during phonation. The microphone is held 12 to 18 inches from the patient's mouth.

tomic in nature and only indirectly reflects the physiology of these structures. Film studies exposed during the phonation of a sustained sound are in themselves not physiologic because this is not a commonly used sound. In addition, no information is gained relative to the finer and transient movements of the tongue and posterior pharyngeal wall that preceded the radiograph.

Cinefluorography with the synchronous recording of sound is being applied to the investigation of a variety of lesions of the pharynx. These include clefts of the palate, palatal paralysis, and foreshortening of the palate. The goal of surgical management of palatal anomalies is the attainment of adequate function rather than anatomical perfection of the palate. Cinefluorography aids in evaluation of the advisability of surgical intervention and in selection of the operative procedure if intervention is indicated. In addition, comparison of pre- and postoperative film records affords a means of evaluation of the effectiveness of different operative procedures.

Cinefluorography is of equal value to the prosthodontist by permitting visualization of the prosthesis in relation to the surrounding oral and pharyngeal structures during the act of speech. The functional adequacy of the prosthetic device cannot be determined by conventional lateral radiography alone.

Despite years of intensive investigation, considerable lack of knowledge still exists relative to speech therapy of palatal defects and to the mechanisms of normal speech production and adequate velopharyngeal closure. Repeated cinefluorographic recordings of patients undergoing prolonged speech therapy should lead to better understanding of these functions and

more effective therapeutic technics. The use of cinefluorography should also prove to be of value in the management of speech defects not associated with palatal abnormalities.

Cinefluorographic records of 3 patients are illustrative: 1 patient with a repaired cleft palate, 1 with palatal paralysis, and 1 with a short palate. The movies do not lend themselves to reproduction, but the following observations were made. When velopharyngeal closure is anatomically impossible, the tongue tends to rise posteriorly in a mound or hump, more than in the normal, to raise the palate. Tongue motion increases with speech therapy as does mandibular motion. Localized bulging of the posterior pharyngeal wall has been described during velopharyngeal closure, but cinefluorography demonstrates a transient but definite forward motion of the entire posterior pharyngeal soft tissues more often than a localized movement. Apparent anatomic apposition of the palate to the posterior pharynx does not necessarily connote functional closure as shown by regurgitation of opaque liquid into the nasopharynx.

This report is a preliminary one but does point out the application of the method for the study of palatal abnormalities. At the present time, more questions are raised than answered with respect to the muscle activity related to speech. It may well be that more rapid film travel coupled with oscilloscopic recording of sound will be necessary for appreciation of finer movements and sounds. Further, a complete analysis of normal palatal and pharyngeal activity will be necessary to appreciate fully the abnormal. In any event, the application of cinefluorography and the simultaneous recording of sound promises an elucidation of physiology in relation to speech, a learned function.

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SUMMARIO IN INTERLINGUA

Studio Cinefluorographic del Functionamento Pharyngee in Relation al Parolar

Cinefluorographia utilisante un intensificator de imagine e le simultanee registration optic del sono representa un technica pro le visualisation del movimentos del palato in le acto del parolar. Iste metbodo ha essite applicate al investigation de patientes pediatric con palato fisse, paralyse palatal, e accurtamento del palato sin fissura. In patientes con fissuras palatal, informationes obtenite per medio de iste studios es de adjuta in le decision de clauder le palato chirurgicamente o de clauder lo per medios prosthetic e plus tarde in le evalutation del adequatia del clausion effectuate. Tal studios etiam promitte contribuer al clarification e evalutation del parolar de patientes pediatric in le curso de therapia a longe vista.

Cinefluorography in Practice

EARL R. MILLER, M.D.

THIS PAPER IS addressed primarily to those contemplating purchase of equipment for taking x-ray movies. Its aim is to provide information regarding facilities required, the investment in time and money, information obtained with the technic, frequency of its use, and its influence on the physician's practice.

To make x-ray movies, the minimum requirements are an x-ray machine, an image intensifier, a movie camera, circuits to interrupt the beam during film movement, and a light meter or automatic brightness control. Although much information has been obtained with 5-inch image intensifiers, field size under these conditions is severely limited. Only the installation of a machine that permits films to be taken of a field not less than 8 inches in diameter should be considered.

Films may be processed by professional processing agencies but, in general, that method has not proved efficient. The films cannot be checked quickly enough and, more important, they are usually developed to a gamma of only 0.6 to 0.7, whereas for x-ray movies development to a gamma of about 1.5 is necessary. Although such forced development results in large grain size, higher fog levels, and less resolution, the high speed and contrast obtained give adequate pictures, requiring a much lower dose of radiation than films developed to a low gamma. For this reason, most workers have processed their own movie films.

The simple technic of unrolling the film into a tank of x-ray developer and gently agitating the solution and the film may be used for processing. For short strips, this technic works well, since the film may be fed by hand from one tank to another with the fingers touching only the film edges. Even with short strips, however, many artefacts are created, drying of film becomes difficult, and the results leave much to be desired. Many workers wind the film on a film hanger in absolute darkness, emulsion side out, which permits handling the strip as a unit when passing it from one solution to the other and facilitates drying. However, only about 30 feet of 16-mm. film can be wound on a 14 × 17-inch hanger, and care must be exercised to prevent overlapping of adjacent films.

Eventually a processing device will be desired that assures films of excellent quality without the handicaps of the more crude systems. These, however, cost several thousand dollars, are difficult to handle, and do not assure the production of high-quality films unless great care is taken in their use.

The dried films are usually first viewed in an editing viewer, of which several types are available. With a viewer that has a shutter, the films can be viewed only at rapid rates if an annoying and fatiguing flicker is to be avoided. In these viewers the light levels are usually adequate. Heat-absorbing glass should be a part of the equipment to prevent burning of films when a single frame is studied. An instrument employing a rotating prism, giving the illusion of continuous motion, has less flicker and therefore is much more satisfactory. However, adjustment of the prisms and the optical system is exacting, and the light levels are inadequate. These units are about 2 1/2 feet long and require desk space in an area of subdued light.

A film splicer is essential for repairing torn film and film with broken sprocket holes, for removing blank spots or areas showing artefacts, and for inserting information and markers. Some simple inexpensive devices are available that work

[1] From the Department of Radiology, University of California, School of Medicine, San Francisco, Calif. Presented as part of a Symposium on Cinefluorography in Medical Practice at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16–21, 1958.

reasonably well if adjusted and used properly. Some higher-priced units capable of splicing without the use of cement or scraping of emulsion are less simple to operate. When kept in perfect adjustment, however, such a unit makes a more permanent and satisfactory splice.

Projection facilities, including a projector, a space for projection, with room for several seats in a darkened area, and a screen, are essential. The ordinary inexpensive projectors are usually unsatisfactory. An efficient projector has the following features: a bright light, not less than 750 watts, a well functioning pull-down mechanism and reversing attachment, facilities for rapid rewinding, ability to show single frames without film burning, and the possibility of projection at various, even very slow, rates without flicker. A flat white mat screen is satisfactory; for a small audience white drawing paper or an old intensifying screen works equally well. Because of the relatively high grain of the film, seating of viewers behind the projector is advantageous. The projection room must, therefore, be of adequate size and well ventilated. Dictating equipment convenient to the editing viewer and the projection facility proves a worthwhile addition.

Since movie films accumulate at an amazing rate, adequate storage facilities are required. The storage space differs from the usual file room for roentgenograms. All cans, reels, and film containers should be retained. Long narrow banks of shelves in a film-filing vault or in a projection room, or drawers to accommodate the usual 100-foot reels, may be provided. Movie films of more than 100 feet require larger reels. A special place for large reels and an indexing system are necessary for ready location. To conserve space, old negatives may be spliced together into 1,000-foot rolls, and, when kept in order, are easy to find. With this storage technic, it is important that large rewinds and projections for large reels be available.

Of value is a special record book designed to meet the needs of the individual department for listing pertinent identifying information and the technic used for the movie. To the patient's regular x-ray number we add an "M" number (*e.g.*, 209876 M 604), recording the M numbers in sequence. In the daily log of the X-ray Department, the x-ray numbers are recorded in sequence, and the M numbers are also noted.

For study in an editing viewer, the negative may be used without resulting damage. In the case of valuable teaching films or those often projected, however, negatives should be preserved and a print made for projection. Routine printing by photographers unaccustomed to processing negatives and prints for the high speeds and contrasts required for x-ray work, will prove useless. It is to the radiologist's advantage to teach the photographer the requirements.

Some workers prefer printing their own negatives. To do so requires a movie printer. Some of these are easily operated, with fair performance; others, more complicated, produce superior results. Many of the gadgets and facilities offered by manufacturers of professional machines are not required by the radiologist whose production of x-ray movies is limited. On complicated machines, however, many devices serve to produce good prints. Whether the amount of film run is large or small, the ultimate quality should be good. This is attained by excellent contact between the negative and print, motion that is constant, good light control, and automatic feed and take-up devices. If sound is used, a variable slit for printing soundtracks must be provided. There should be separate control of the light to which the print and the sound-track are exposed to obtain the best quality of each. In general, the simple machines do not provide perfect contact between the negatives and the print during exposure.

We will now consider the cost of installing, in an empty leaded x-ray room, equipment intended for conventional fluoroscopic and radiographic examinations as well as for movies. A fluoroscopic table

with a spot-filming device and phototimer, a generator and control, an over-the-table tube and tube stand, and accessories are necessary. The list price for such a basic unit is approximately $20,000. A 5-inch image intensifier costs approximately $6,500 to $8,000. On certain units it is possible to add a movie camera and the equivalent of a brightness meter for under $1,000. The installation of a higher-grade camera and automatic brightness control costs about $5,000 to $6,000. Thus, a 5-inch intensifier and movie attachment with a brightness meter or automatic brightness control will cost between $6,500 and $13,000 depending on equipment desired. Changing the 5-inch intensifier to a larger one will add $4,000 or $5,000. Thus, the total cost of this relatively simple equipment will be in the order of $32,000 to $39,000. A Lumicon unit would increase the total cost to approximately $50,000.

Equipment for processing films ranges between zero and $7,000. An editing viewer costs about $130, a splicer between $10 and $800, and an adequate projector between $400 and $1,600. Thus, the cost of accessories is from $550 to $9,500, for work only with negatives. The price of printers ranges from about $200 to thousands, depending upon the quality of the instrument. Extra rewinds for film and motor-driven take-up tools are necessary if inexpensive printers are used.

All of this adds to a high cost for equipment and for space normally not provided in a roentgenologic department. Furthermore, in studying the movies, an hour or so per case is not unusual. Much time is also consumed in editing a film and still more time in preparing titles, unless these are done professionally. The cost of professional film titling is high, however, and normally the film is not titled if it is to be used only for diagnosis. An untitled film usually requires the presence of the person who made it, for audible comments to aid in the interpretation of data presented, or much time and money must be spent to produce visible titles. In practice, this hidden expense becomes great.

We have found the use of sound invaluable. It produces a time marker for events, permits the movie to be titled at the time it is made, and records the patient's reaction to a procedure, indicating, for instance, the presence or absence of pain.

Professional processing costs about 3 cents a foot for developing the negative, and about 6 to 7 cents a foot for printing. Thus, the processing work runs between $3 and $10 per 100 feet of film, depending on whether a negative only or a print is required.

So far we have considered the simple systems that will be relatively trouble-free and require little maintenance. If television systems are included, these require maintenance and for the more complex ones specially trained technicians are needed to keep them in operation.

Studies of the pharynx in speech and in swallowing, the esophagus and cardioesophageal junction, the heart in angiocardiography, the urinary bladder, and the motion of joints, practically constitute the field of usefulness of the cinefluorographic technic. These studies are characterized by motion in an area small enough to be seen on or followed by the screen, and a rapid component of the motion which tends to be repetitive or cyclic.

In the present state of the art, movies are finding their greatest use in research and teaching. Through them we begin to understand more about speech and its correction in patients with cleft palate. They contribute to an understanding of motion of the urinary bladder in obstruction and after prostatic operations; the motion and direction of flow of urine through prostheses for the bladder; the timing and position of the flow of the blood through defects in the heart; the timing of pain and sounds in spine and joint motion; and the acceleration of movements.

The student learns to appreciate the "aliveness" of anatomical parts he sees fixed and distorted in the cadaver. He sees the functions of various muscle groups

in the extremities, throat, bladder, and gastrointestinal tract, movement of the diaphragm, the change in the lung and bronchi on breathing, and the action of joints. In physiology, the effect of the Valsalva and Müller maneuvers, of pressure on the carotid sinus, of inversion of the body, and the effect of movement and pressure changes in the gut and bladder are demonstrated. In pharmacology, the effects of drugs on heart rate and on muscle tone, and the rate at which these act, can be shown.

In teaching, the value of the record is independent of the rate of change of the event. Any movement can be demonstrated with profit. With the use of bright images, the whole class at one time is able to view these movements, neither dark adaptation nor patient exposure being required.

In research, movies permit the study and restudy of an event, with attention focused upon different structures at different times. They also provide information on the presence of a "fast" component that may have been missed on fluoroscopic study, and the use of slow-motion film provides information not attainable by other means.

When placed beside its tremendous usefulness in teaching and research, the value of cinefluorography in patient service becomes almost insignificant. This observation is of paramount importance to those who look to the technic to be of great import in the private practice of radiology. If a physician sees significant numbers of patients with impaired action of the pharynx or congenital anomalies interfering with its function, heart disease, urinary bladder dysfunction, esophageal disease, or joint dysfunction, then cinefluorography may be expected to provide valuable information. It is not likely, however, that it will make an important impact on his practice, even in twice this number of conditions.

Movie films can never give the detail and resolution provided by the still radiograph. However, the eye integrates the information on several succeeding frames when these are projected as a movie so that more detail is visible than on any single frame.

On the other hand, the dimension of time is gained when studying the changes in organs by the movie technic.

In certain general conditions movies become of great value. Exceedingly rapid motion can be studied only with films taken at rapid rates. Only small films can be moved at these high rates and they are ideal for projection as a movie. The eye is adept at discerning small movements when they are thus presented. Through the use of this technic, motions that are missed on serial examination of single films, even though they may have been taken at rapid rates, can easily be observed.

Movies are particularly useful in the examination of motion that is generally slow but has in it a "fast" component, the time of which is uncertain. An example is the motion of the diaphragm during a hiccup. Such a study can only be made by having the examination proceed during the predictable slow phase and catching the fast phase when it appears.

In the study of even some slow motions movies are useful. Dr. Malcolm D. Jones, working in our department on the motion of the spine, has demonstrated that not only is the total range of motion important (this can be determined by films taken at the extremes of motion), but the way the part approaches its end-point may be of even greater significance. He also pointed out that single films may not be obtainable at certain critical points in a motion. For example, a patient with severe pain at a particular point in motion will not be able to hold his position long enough for it to be recorded on an ordinary radiograph, whereas he may be able to go through the point of pain for an instant, during which the movie records the position. Through the use of movies Dr. Jones has learned the importance and meaning of certain abnormalities demonstrated on the plain film of the spine and other joints, and for these he no longer takes movies. How-

TABLE I: USE OF AND INCOME FROM X-RAY MOVIES

	Percentage of Patients*			Percentage of Income		
	Private	Clinic†	Total	Private	Clinic	Total
Fluoroscopy	12.7	15.2	14.0	23.5	21.2	22.6
Tomograms	0.45	0.67	0.57	0.86	1.1	0.96
Movies	0.11	0.53	0.31	0.16	0.088	0.13

* Data from University of California Medical School, San Francisco, H. C. Moffitt Hospital.
† Clinic, staff, and research patients.

ever, in patients whose plain films are negative, movie studies have yielded a high percentage of positive diagnoses. It is reasonable to suppose that this area will ultimately provide the greatest usefulness for cineroentgenography.

In order to give some degree of quantification to the above remarks on the usefulness of x-ray movies, the percentage of patients having fluoroscopic examinations, tomograms, and movies, and the percentage of income derived from these sources were recorded. Fluoroscopy was chosen because radiologists have a "feel" for the amount of time and energy invested in that procedure, and tomograms because they are one of the less common and more expensive examinations. In this respect they resemble movies. The figures are presented in Table I. From this it is evident that even fewer movies than tomograms are done. In spite of the high investment in funds, space, and time required for movies, the relative income is much lower than for either fluoroscopy or tomography.

Working with x-ray movies is a rewarding experience. Whole new fields of interest have been created and we are approaching a better understanding of a number of phenomena through their use. It can be predicted with fair certainty that with this medium even greater knowledge will be gained in the future.

SUMMARY AND CONCLUSIONS

X-ray movies are of tremendous value in teaching some aspects of anatomy and physiology in the medical curriculum. In certain fields of study and research they have provided information attainable in no other way.

At the present time they have a small though definite place in the service of selected patients. The investment of funds, time, and space is inordinately great when compared to the income that can be derived from the use of the technic in patient service.

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SUMMARIO IN INTERLINGUA

Le Cinefluorographia in le Practica

Cinematogrammas radiologic es de tremende valor in docer certe aspectos de anatomia e de physiologia in le curriculo medical. In certe campos de recerca illos ha providite informationes que non pote esser obtenite alteremente. Studios del pharynge in le acto del parolar o inglutir, del esophago, del junction cardioesophagee, del corde sub scrutinio angiocardiographic, del vesica urinari, e del articulationes in motion es le areas constituente al tempore presente le campo del utilitate practic de technicas cinefluorographic. Iste studios es concernite con movimentos intra un area satis restringite pro esser visibile in le ecran e specificamente con componentes de motion que tende a repeter se.

Currentemente le cinefluorographia occupa un modeste sed definite loco in le studio de patientes seligite. Illo es capace a provider utile informationes in le supramentionate areas, sed al tempore presente

il non es probabile que illo pote impinger importantemente super le practica del medico individual.

Es discutite, ab un puncto de vista practic, le apparaturas requirite, le disponibilitate de illo e su costo, e etiam le expensa in tempore resultante de su application. Es monstrate que le investimentos de moneta, tempore, e spatio es disproportionatemente pesante in comparation con le revenitos que pote esser expectate ab le application clinic de iste technica.

DISCUSSION ON SYMPOSIUM ON CINEFLUOROGRAPHY IN MEDICAL PRACTICE

(Papers by Lusted; Hodges and Moseley; Abrams; Klatte, Campbell, and Lurie; Tristan, Benjamin, and Watson[1]; Kirkpatrick and Olmsted; Miller)

R. H. Morgan, M.D. (Baltimore, Md.): In the series of seven papers you have just heard, an enormous amount of data on cinefluorography has been presented to you. It perhaps might be worthwhile, at this time, to epitomize this material and to emphasize a few of the more important points.

A review of the subject cannot help but impress one with the fact that cinefluorography is a rapidly growing modality in radiology that is currently having its greatest application in areas of clinical medicine where there is need to record rapidly occurring physiological phenomena. These areas include the fields of cardiology, gastroenterology, urology, and respiratory disease.

Cinefluorography has been given great impetus and indeed has been made a practical technic by developments in screen intensification. The markedly increased efficiency in the utilization of the information contained in the x-ray beam, made possible by the intensification process, has resulted in cinefluorograms of superb quality with relatively low radiation doses.

As yet, cinefluorography may appear formidably expensive to many radiologists. These costs have perhaps been overemphasized. Since screen intensification for conventional fluoroscopic procedures is rapidly becoming a necessity for the practice of good radiology, and since intensifiers are sufficiently flexible to double as fluoroscopes and cine devices, the provision of a cinefluorographic facility in the well equipped office or department can be achieved without raising the percentage cost of the installation by a large factor.

Another point which may be made is the rapidly increasing simplicity of apparatus and technics in cinefluorography. As Dr. Klatte and his associates have so well pointed out, simple 16-mm. cameras are quite able to record essentially all of the detail yielded by the intensifier, and the resulting films can be processed rapidly by the newer x-ray film processing machines.

Although Dr. Lusted spoke of many new developments which are in the making in the field of screen intensification, I think it should be stated that, from now on, these developments are likely to occur at a relatively slow rate and that one should no longer delay the acquisition of screen intensification equipment, with or without cine attachments, in the anticipation that radically better devices will soon be available. If one does delay, one is likely to find after a period of time that the world has passed by, with consequent loss of the very substantial assistance which screen intensification fluoroscopy and cinefluorography are today able to provide. Improvement in apparatus, to be sure, will come over the years but is not likely to be revolutionary.

Of the screen intensification devices available today, only the image-tube types can be considered suitable for wide radiological application. Although the future holds considerable promise for the apparatus described by Dr. Moseley, this equipment is likely to be satisfactory only for experimental use for some time. Also, the solid-state panels about which you have read will require one or more scientific break-throughs in their design before they are useful products.

There are perhaps two other technical points which should be made concerning screen intensifiers. Dr. Lusted has spoken about the possibility of screen intensification devices of sharply increased resolution in the not distant future. I feel that this possibility is quite remote. Present-day image-tube intensifiers utilize essentially 100 per cent of the information contained in the x-ray beam. Hence the only way remaining for an improvement in resolution is an increase in the radiation intensities used during fluoroscopy and cinefluoroscopy. This, most of us are unwilling to follow. This brings me to the second point. Much has been said about the reduced radiation exposures to patients which may be achieved through screen intensification, whereas only little has been said of the greatly increased clarity of detail afforded. Although screen intensification makes it theoretically possible to reduce radiation dose by as much as 20 times, one always sacrifices detail in such a process. It has been my experience in practical day-to-day fluoroscopy with intensification to accept only a slight reduction of dosage, perhaps of two or three times, and thereby to retain the clearer, sharper image provided by an intensifier operating closer to conventional fluoroscopic levels.

I shall not comment on the several papers which demonstrated so beautifully the application of cinefluorography to specific clinical problems. The films you have seen speak for themselves.

[1] To be published later.

Wedge Pulmonary Arteriography

Its Application in Congenital and Acquired Heart Disease[1]

A. L. LOOMIS BELL, JR., M.D., SEIICHI SHIMOMURA, M.D.,[2] W. JAMES GUTHRIE, M.D.,[3] HERBERT F. HEMPEL, M.D., HUGH F. FITZPATRICK, M.D.,[4] and CHARLES F. BEGG, M.D.[5]

THE ASSOCIATION of pulmonary arterial lesions with congenital and acquired cardiac defects has been recognized for a number of years. These arterial lesions can be considered of two general types. In one, muscular hypertrophy, thickened elastic layers of pulmonary arteries of all sizes, and a thickened muscular layer of arterioles are encountered. In the other type, obliterative intimal proliferation and fibrosis involving muscular arteries of 300–500 micra are associated with thin-walled and dilated smaller arteries and arterioles (1, 2).

Cardiac catheterization technics have permitted measurements of pulmonary artery pressure and flow and, thus, calculation of pulmonary vascular resistance. Such hemodynamic studies, when correlated with the histopathological changes in the pulmonary vessels, have clarified the functional significance of these vascular lesions. Since it is the smaller pulmonary arteries and arterioles that are involved, clinically applicable methods of visualizing the smaller branches of the pulmonary arterial tree should prove useful in the study of the occurrence, pathogenesis, and differentiation of these lesions and should be helpful in the investigation of their relationship to the hemodynamic pattern and in the selection of candidates for repair of the associated cardiac defects.

Pulmonary arterial lesions are at present defined by lung biopsy. Indirectly, their presence can be deduced either from plain radiographs of the chest or from hemodynamic data obtained at cardiac catheterization, indicating an increased pulmonary resistance. Some workers have visualized the main pulmonary arterial trunk and its major branches by venous angiography and pulmonary arteriography (3–5), although certain studies were concerned with pulmonary disease (6, 7). Others have defined the x-ray appearance of the pulmonary vascular lesions by postmortem dye injection technics (5, 8–12).

Fig. 1. V. L. Normal pulmonary arteriogram of a 12-year-old girl without heart disease, with normal pressures and normal pulmonary blood flow. See text for description.

It is the purpose of this report to describe a clinical technic for visualizing radio-

[1] From the Cardiopulmonary Laboratory, Department of Medicine, and the Department of Radiology, St. Luke's Hospital, New York, N. Y. This work was supported in part by the New York Heart Association. Presented in part at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16-21, 1958.

[2] Vincent Youmans Memorial Research Fellow in Medicine.
[3] Nathan Hofheimer Research Fellow in Medicine.
[4] Assistant Director, Department of Surgery.
[5] Director, Department of Pathology.

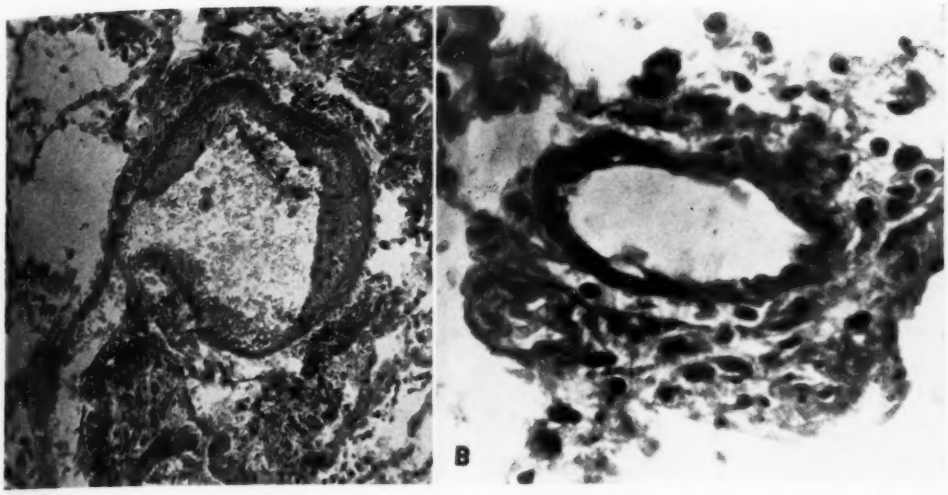

Fig. 2. A. Artery (320 micra) and arteriolar branch, in a 17-year-old male with no cardiovascular disease. Note normal muscular and intimal coats of artery, with a wide lumen of both artery and arteriole.
B. A 50-micra arteriole from the same normal lung as shown in A. Note thin wall with wide lumen. Hematoxylin-eosin stain.

graphically the small pulmonary arteries and to outline the preliminary results of the application of this technic in 38 patients with congenital or acquired heart disease, studied between April 1957 and May 1958.

METHODS

During right heart catheterization, a No. 7 Cournand catheter is manipulated into a pulmonary artery "wedge" position. Care is taken to wedge the catheter tip in an area of clear lung field free from mediastinal shadow, diaphragm, or scapula. After the wedge position is confirmed by a pressure tracing, and while the patient holds his breath at full inspiration, 2 or 3 c.c. of 70 per cent sodium 3-acetamido-2,4,6-triiodobenzoate (Urokon) is introduced through the catheter at an injection pressure of approximately 100 mm. Hg, as measured at the proximal end of the catheter. During the injection, an x-ray exposure is made. The catheter is immediately flushed with 5 to 10 c.c. of physiologic saline and a repeat pressure tracing is obtained.

For obtaining the roentgenogram, an overhead x-ray tube with a focal spot of 2 sq. mm. is utilized, with a target-film distance of 36 inches. A cone extending to within a few inches of the chest reduces scattered radiation. The film, Kodak non-screen film in a paper cassette, is placed directly beneath the patient's chest. Exposure factors, dependent on the anteroposterior diameter of the chest and thickness of the chest wall, vary from 90 to 110 kv, at 300 ma, and 1/30 to 1/60 second. The resultant film is processed by the usual developing technic.

The arteriograph thus obtained is a 1.1 to 1.2 times enlargement of the contrast-filled vessels, due to projection. For better definition, the film is enlarged approximately two times. Further enlargement has been unsatisfactory because of the coarse grain of the x-ray film.

The actual intraluminal diameter of the contrast-filled vessels can be estimated by multiplying their diameter, as measured on the final radiograph, by a factor derived from the ratio of the actual diameter of the cardiac catheter to its apparent diameter on the film. The actual diameter of the cardiac catheter tip is determined by micrometer measurement.

In preliminary animal experiments, a

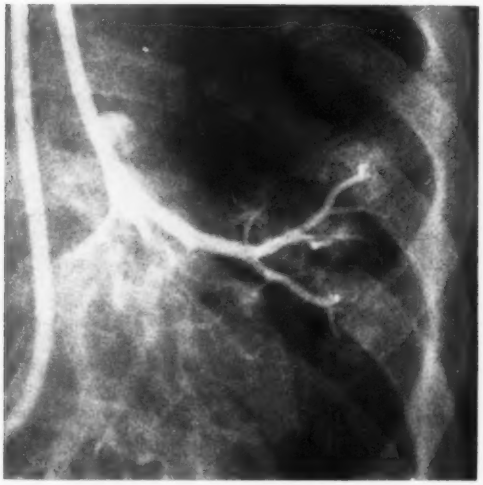

Fig. 3. J. F. Wedge pulmonary arteriogram of a 5-year-old boy with a large ventricular septal defect. Pulmonary artery pressure 135/84, 98 mm. Hg. Pulmonary flow reduced to 80 per cent of systemic flow. Note sparse arborization and abrupt termination of some arteries, others narrow to fine tortuous channels. There is lack of background filling. See text for discussion.

Fig. 4. M. S. Wedge pulmonary arteriogram of 18-year-old male with truncus arteriosus. Pulmonary artery pressure 126/58, 86 mm. Hg. Pulmonary flow reduced to 63 per cent of systemic flow. Catheter tip unwedged (lies free in small pulmonary artery). Note sparsity of arborization and abrupt narrowing of vessels.

number of alternate procedures were tried before reaching the above described technic. Radiopaque media of 30 to 90 per cent were tested, with 70 per cent concentration resulting in the most satisfactory pictures. Larger quantities of medium were injected with less satisfactory definition of the small pulmonary arterioles. An injection pressure of 100 mm. Hg seems to provide adequate filling of the vessels, both in the normal and abnormal arterial tree, yet does not result in extravasation into the lung parenchyma or in lung infarction.

RESULTS

According to a hemodynamic classification, four categories of patients have been studied. Subjects with a normal pulmonary artery pressure and pulmonary blood flow, a normal electrocardiogram, and a "functional" murmur as the only clinical evidence for heart disease served as controls. Patients with markedly increased pulmonary artery pressure and decreased pulmonary blood flow due to a large ventricular septal defect, truncus arteriosus, or patent ductus arteriosus comprised the second group. In the third category were patients with normal or only slightly increased pulmonary artery pressure and increased pulmonary blood flow resulting from an atrial septal defect and/or anomalous pulmonary venous drainage. The final group was made up of patients with increased pulmonary artery pressure related to increased left atrial pressure with normal pulmonary flow, as in mitral stenosis.

The wedge pulmonary arteriogram (WPA) of a typical normal patient (V.L.) is shown in Figure 1. The catheter is wedged in a pulmonary artery with a luminal diameter of 2.5 mm. There is abundant arborization of small arteries of 2,000 micra internal diameter, with filling of the smaller arterioles and capillaries producing distinctive background markings. This radiographic picture is indicative of normal vasculature as illustrated in Fig-

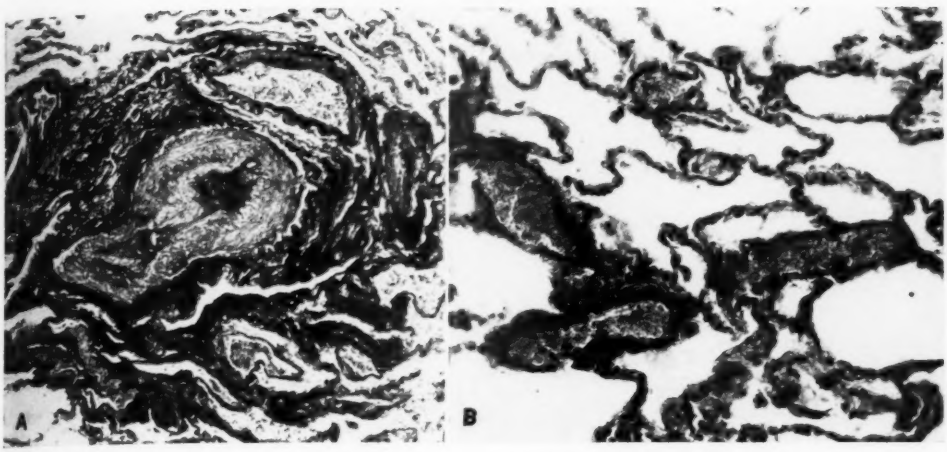

Fig. 5. A. Artery (330 micra) and branch from the same patient as Fig. 4. Marked occlusive intimal fibrosis and adventitial thickening.
B. Dilated thin-walled arterioles in same patient. Masson's trichrome stain.

ure 2, *i.e.*, arteries and arterioles with thin walls and wide lumina.

The patients in Group II have in common a markedly elevated pulmonary artery pressure and reduced or normal pulmonary blood flow related to various congenital defects. Typical wedge arteriograms of these patients are shown in Figures 3 and 4. These show sparsity of arborization of the small pulmonary arteries, abrupt termination of arteries 500 to 1,200 micra, and abrupt narrowing of vessels of similar size into fine tortuous channels. The background markings of normal capillary filling are not visualized. This "pruned tree" radiographic picture results from widespread occlusive intimal fibrosis present in arteries of from 300 to 1,200 micra in diameter, as is shown in the histologic sections taken from one of these patients (Fig. 5). In contrast, the smaller arterioles are dilated, thin-walled, and tortuous.

Group III is made up of patients with increased pulmonary blood flow and normal or only slightly raised pulmonary artery pressures. The arteriograms of 2 of this group are shown in Figures 6 and 7. These are not clearly differentiated from the normal. Extensive arborization is seen, and capillary filling seemingly more abundant and more prominent than normal is particularly evident in Figure 6. The typical normal appearing thin-walled and dilated small arteries in these cases are shown in the biopsy specimen (Fig. 8) from the case shown in Figure 7.

Group IV patients have elevated pulmonary artery pressures related to high left atrial pressures from mitral stenosis. Figures 9 and 10 are arteriograms of 2 of these patients. Decreased arborization of an intermediate degree is apparent, with sparsity but not absence of background markings from decreased arteriolar and capillary filling. No abrupt termination of arteries is seen. This apparent decrease in arborization and small-vessel filling may be attributed to muscular hypertrophy of arteries, with narrowing of the lumen, and to the presence of a muscular media in segments of arterioles normally without a muscular coat, as shown in sections from one of these patients (Fig. 11). Intimal fibrosis resulting in partial occlusion is found in some of the muscular arteries.

DISCUSSION

These preliminary observations indicate that the appearance of the wedge pulmonary arteriogram provides an accurate reflection of the condition of the pul-

Fig. 6. V. G. Wedge pulmonary arteriogram of a 34-year-old female with an atrial septal defect. Pulmonary artery pressure 39/10, 16 mm. Hg. Pulmonary flow greatly increased, to 470 per cent of systemic flow. Extensive arborization and abundant background filling are evident.

Fig. 7. E. M. Wedge pulmonary arteriogram of 13-year-old male with an atrial septal defect and anomalous pulmonary veins with pulmonary flow increased to 230 per cent of systemic flow; normal pulmonary artery pressure.

monary vasculature. The typical abnormal wedge arteriogram of patients in whom a long standing common pressure in aorta and pulmonary artery has led to increased pulmonary resistance and decreased pulmonary flow presents a striking picture, easily differentiated from the normal. In our experience to date, this appearance correlates well with the histologic picture of the pulmonary vasculature as seen in these patients, where the widespread occurrence of obstructive intimal lesions of larger muscular arteries (300 to 600 micra) is the major cause of increased resistance to pulmonary flow (1, 2, 11, 13, 14). This pattern has been found, but not consistently, in association with ventricular septal defect, truncus arteriosus, and patent ductus arteriosus, and in older patients with atrial septal defect. If, as seems likely, these lesions are irreversible, the high pulmonary resistance is fixed and surgical correction of the associated cardiac defect is contraindicated. Application of wedge pulmonary arteriography may provide a reliable clinical method for detecting this stage of the pulmonary vascular response.

The wedge arteriogram in patients with increased pulmonary blood flow and normal pressure, at our present stage in this investigation, shows a picture not differentiated with certainty from the normal. An impression is gained of increased arborization and capillary filling in many of the group, which corresponds to the histologic demonstration of dilated and tortuous small vessels seen in lung biopsies from these patients undergoing repair of the atrial septal defects. In the late stage atrial septal defect with cyanosis and severe pulmonary hypertension and intimal fibrotic changes, the wedge arteriogram presents the characteristic picture of Group II (1, 13).

Patients with mitral stenosis and significant pulmonary hypertension show muscular hypertrophy in the small arteries and arterioles (1, 12). On the wedge arteriogram, narrowing of the lumina due to hypertrophy appears to result in a lessening of arborization and in a lack of adequate background filling, giving the impression of abnormality. In a fair number of patients with moderately severe pulmonary hypertension, however, arboriza-

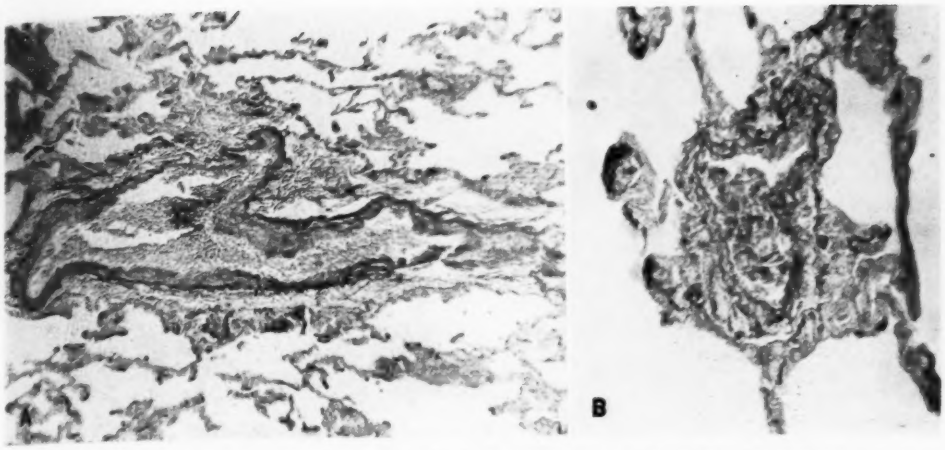

Fig. 8. A. Thin-walled artery of about 140 micra diameter, showing thin wall and open lumen.
B. Dilated thin-walled arteriole of 70 micra diameter from the same patient as Figure 7. Aldehyde fuchsin stain.

Fig. 9. M. M. Wedge pulmonary arteriogram of a 28-year-old female with rheumatic heart disease, mitral stenosis. Pulmonary artery pressure 44/29, 33 mm. Hg. Left atrial pressure 17 mm. Hg. Decrease in arborization and background filling are seen. (The contrast medium fills two arteries partially superimposed in this view.)

Fig. 10. H. B. Wedge pulmonary arteriogram of a 39-year-old male with rheumatic heart disease, mitral stenosis. Pulmonary artery pressure 41/25, 29 mm. Hg. Left atrial pressure 19 mm. Hg. See text for description.

tion appeared perfectly adequate, though background filling was inadequate. Differentiation from the normal could not be made with any degree of certainty in some of these cases. In patients with marked pulmonary hypertension, a definitely abnormal "pruned tree" appearance was demonstrated. A detailed report of these studies is being prepared (15).

The preliminary nature of these observations must be emphasized. Occlusive intimal changes in the muscular pulmonary arteries of 300 to 1,000 micra are readily visualized by the technics described. Narrowing of the lumina of the arteries and arterioles of smaller size are less conclusively demonstrated by the absence of normal "background markings."

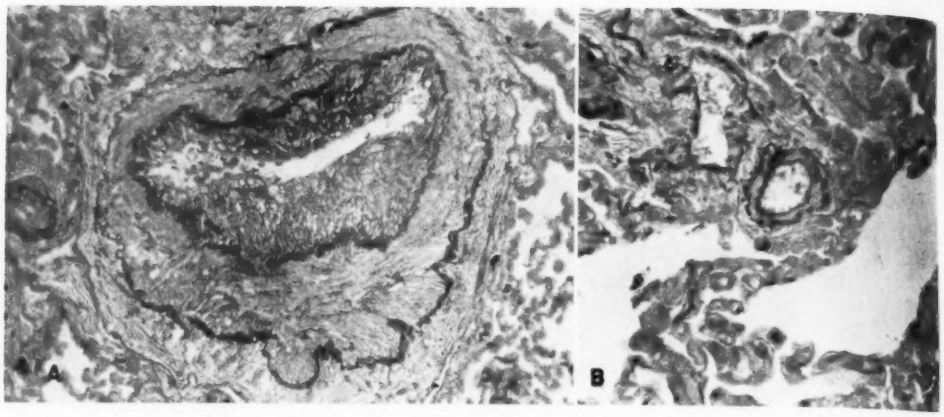

Fig. 11. A. Artery (225 micra) from patient in Figure 10, showing adventitial thickening, medial hypertrophy, and intimal proliferation resulting in partial occlusion.
B. Arteriole (45 micra) showing muscular hypertrophy. Aldehyde fuchsin stain.

Recent animal work utilizing a fine grain x-ray film which permits higher magnification and detailed study of the smaller vessels demonstrates that better delineation of these smaller vessels is feasible, and that these methods can be applied clinically (16). These latter methods should materially enhance the value of the technic in conditions where the smallest pulmonary arteries and arterioles are primarily involved by the pathological process.

Using apparently similar injection technics, but with a conventional spot-film device for film exposure, O'Loughlin reports less satisfactory definition of the pulmonary arterial vasculature (17). In the authors' experience it has been found necessary to use non-screen film and as great a target-film distance as possible for satisfactory delineation of the small vessels.

Untoward effects of the procedure have consisted of a transient paroxysm of coughing in approximately one-half of the patients. Cough may occur fifteen to thirty seconds after injection and may last as long as a minute. The usual bitter taste associated with iodinated preparations is present in most cases. A pulmonary infarction-like process developed in 2 cases. M.S., our first patient, received 10 c.c. of the medium and this was not immediately washed out with physiologic saline, a practice which is now routine. The day following the catheterization, pleuritic chest pain without fever and a mild nonproductive cough developed, with fine râles and a density localized by x-ray in the area of the wedging. This cleared in four days. A second patient early in the series received a 5-c.c. injection, and again this was not immediately flushed. She also reacted with cough, some chest pain, and an infiltrative density on the chest film. This density decreased in size but remained, though physical symptoms and signs disappeared. At autopsy, following ligation of a large patent ductus arteriosus, a 2-cm. organizing pulmonary infarction was found, corresponding to the site of wedging. Two patients with mitral stenosis coughed up small quantities of blood-streaked sputum briefly on the day after the study, without other evidence of infarction.

It is not clear from this experience whether the infarctions were due to the contrast material itself or to the wedging of the catheter, or to a combination of the two. In view of the fact, however, that prior to use of this injection technic, pulmonary infarction had seldom complicated our wedge procedure, it is felt that the injection was of primary significance. Controlled injection pressure and

prompt flushing with physiologic saline solution, together with a rapid procedure, necessitating a minimal period of wedging, have virtually eliminated this complication.

SUMMARY

A clinical method of visualizing radiographically the small pulmonary arteries is described. In preliminary studies the wedge pulmonary arteriogram correlates well with the pulmonary vascular lesions and abnormal hemodynamics seen in patients with congenital and acquired cardiac defects. The method should provide a safe clinical means for differentiating those cases in which occlusive and presumably fixed changes in the pulmonary vascular resistance have occurred.

ACKNOWLEDGMENTS: The authors gratefully acknowledge the assistance of Mr. Lawrence Novey and Mr. W. S. Cornwell of Eastman Kodak Co., in developing the exposure technic described, and the technical assistance of Messrs. Joseph Davidse and Frank Kleczek in performing these studies. Dr. A. P. Fishman made helpful suggestions during the preparation of this manuscript.

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SUMMARIO IN INTERLINGUA

Arteriographia Pulmonar Cuneate: Su Application in Congenite e Acquirite Morbo Cardiac

Es describite un technica clinic pro visualisar le micre arterias pulmonar. Resultatos preliminari del application de iste technica a 38 patientes con congenite o acquirite morbo cardiac es presentate. In iste technica le medio de contrasto es introducite via un catheter que ha essite manipulate a in un position cuneate in le arteria pulmonar.

Le arteriogrammas assi obtenite se ha monstrate ben correlationate con le lesiones pulmono-vascular demonstrate per medios histologic e con le anormalitates hemodynamic in ambe gruppos de patientes. Es opinate que arteriographia pulmonar a catheter cuneate es un methodo promittente in le differentiation del casos in le quales occlusive e presumitemente fixe

alterationes del resistentia pulmono-vascular ha occurrite.

In 2 casos del presente serie, infarcimento pulmonar sequeva le intervention, sed iste complication ha essite eliminate plus o minus completemente per medio de caute regulation del pression de injection e de un prompte elution del catheter con physiologic solution salin si tosto que le exposition roentgenographic es complite.

DISCUSSION

Bernard J. O'Loughlin, M.D. (Los Angeles): It is a real pleasure to be able to discuss such a fine contribution as that of Dr. Bell and his associates. Dr. Bell's fame has reached the west coast and, while I did not have an opportunity to see his paper, I had heard enough about it so that I knew it would be an excellent contribution. We have been trying to do wedge-angiography for about the same length of time that he has. We use a slightly simpler technic, I believe, but we have not achieved Dr. Bell's ability to interpret the results.

When wedging the heart catheter for wedge-pressure studies, we introduce 2 or 3 c.c. of the contrast medium and make a "spot" film with conventional technic. Our films are not of the same sharp quality as those that you have seen this morning but the technic is very easy. When we try to predict what the degree of hypertension will be by looking at films, not knowing what the pressure in the pulmonary arterial system is, we do not do well.

Dr. Bell's procedure obviates the need for pulmonary biopsy in patients who are being considered for corrective cardiac surgery. Biopsy is frequently considered in these patients because a long standing and severe pulmonary hypertension is often made worse by correction of shunts or repair of defects. While positive findings may contraindicate operation, negative findings may indicate the advantage, otherwise unsuspected, to be obtained by surgery.

I think that we have been highly privileged to hear this presentation and that it is going to be a still greater privilege and pleasure to see it in print.

Pulmonary Hypertension Due to Pulmonary Arterial Coarctation

KARL H. FALKENBACH, M.D., NORMAN ZHEUTLIN, M.D., ANDREW H. DOWDY, M.D., D.Sc., and BERNARD J. O'LOUGHLIN, M.D., Ph.D.

WITH IMPROVED diagnostic methods many diseases which were previously grouped together as idiopathic can now be separated into etiologic categories. Essential pulmonary hypertension may succumb to reclassification, since several types are now found to be distinguishable on the basis of definite radiological and pathological changes (1, 27, 54). It is not only our duty to refine these idiopathic categories, but it is our privilege as physiologically oriented radiologists to try and understand the basic changes which make this refinement possible (49).

There have been many recent reports (2, 6, 11, 14, 20, 41, 45, 48, 51, 53, 55, 58, 60) on supravalvular or postvalvular constriction, coarctation, or stenosis of the pulmonary arteries. Four mention the association of pulmonary hypertension with this condition (2, 11, 14, 41). It is our observation that the two are always associated. Four reports have appeared in the radiologic literature. This is apropos, since coarctation of the pulmonary artery can be diagnosed radiographically.

Despite the manifest recent interest in the radiological anatomy of the pulmonary arteries and in the physiology of the lesser circulation, coarctation of the pulmonary artery was not even discussed in the recent International Symposium on the Pulmonary Circulation sponsored by the Chicago Heart Association in March 1958. It seems that up to the present the relationship between pulmonary hypertension and pulmonary coarctation has not been firmly established or generally recognized.

METHOD OF STUDY

Three general methods of study are presented: first, an analysis and review of our own cases; second, an attempt to produce pulmonary arterial coarctation anatomically and to observe the effects, if any, upon the pulmonary blood pressure; third, a review of the world literature on the pulmonary artery coarctation made in an attempt to detect patterns, similarities, or syndromes which would prove helpful in the diagnosis. From clinical and angiocardiographic observations it appeared to us that such a relationship was a very likely probability. The intermediary between the anatomical malformation and its physiologic manifestation could be a hypothetical humoral material, a neurogenic response or a hydrostatic reaction to the mechanical constriction observed. This problem seemed to invite a combined radiological and physiological experimental attack. The major premise, however, is the only one which we have tested. The secondary hypotheses are in the process of exploration.

CLINICAL OBSERVATIONS

Seven children who were seen in the cardiac clinics of the University of California (Los Angeles) were found to have pulmonary arterial coarctation. All of these children had pulmonary hypertension. During this same three-year period 68 other children with pulmonary hypertension were observed among 330 who had had diagnostic heart catheterization and/or angiocardiography. Three types of coarctation were distinguished, central or scodaic, peripheral (usually multiple) (20, 58), and main branch constriction. Cases are too few to state the frequency of occurrence of these types with any accuracy. There may be a fourth type, a transitory contraction which we have seen on some angio-

[1] From the Department of Radiology, University of California at Los Angeles, School of Medicine. Supported by a grant from the Los Angeles County Tuberculosis and Health Association. Presented at the Forty-fourth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 16–21, 1958.

TABLE I: DETAILS OF

Case	History	Murmur	Thrill	P_2
I	Murmur since 1 yr. of age	Grade II, harsh systolic, transmitted to back. Less loud in 2d and 3d left intercostal spaces anteriorly	None	Greater than A_2. Split
II	Murmur since 6 mo. of age. Dyspnea on exertion last 6 mo. Increase of dyspnea and ankle swelling last 2 mo.	Grade IV systolic in 2d and 3d left intercostal spaces, less marked on right, in same spaces. Murmur transmitted to back	Systolic, 2d left intercostal space	Greater than A_2. Split
III	$1^1/_2$ mo. premature. Birth weight 3.9 lb. Blue at birth; later cyanotic when crying. Murmur since birth	Grade IV systolic in 3d left intercostal space	None	Greater than A_2.
IV	Blue at birth. Murmur since 3 days of age. Mild cyanosis at 2 yr.	11-20-53: Grade II systolic in 2d and 3d left intercostal spaces	11-20-53: None	A_2 greater than P_2, 6-16-56
	Cyanosis at 5 yr. moderately marked	6-16-56: Grade IV systolic in 3d left intercostal space	6-16-56: Systolic thrill in 3d left intercostal space	
V	3 weeks premature. Heart murmur at 5 mo. Slow development. Congenital cataract	Harsh systolic, Grade IV, in 3d right intercostal space, radiating into neck		Diminished
VI	Cyanosis since birth. In oxygen first 2 mo. Finger and toe clubbing	Grade III systolic in 2d and 3d intercostal spaces	None	Greater than A_2
VII	Dyspnea since birth. Digitalis last 2 wk. Cyanosis	Grade IV systolic, blowing over precordium and back, maximal in 4th left intercostal space	Systolic	P_2 split, accentuated

cardiograms but have not confirmed at surgery, autopsy, or by catheter "pull-back" pressure tracings.

The brief case reports which follow give the essential data in chronological form. Much of the same material is presented in tabular form (Table I). Table III summarizes the previously reported cases.

CASE I: A normal appearing white female was born on Dec. 7, 1950. In November 1956 the mother was told by the school doctor that the child had a heart murmur. She then remembered that the baby had had trouble breathing and used to sleep with pillows. During the last three years all symptoms had disappeared, although the patient was not as active as her classmates and tired more easily. When brought to the hospital on May 10, she appeared well developed and well nourished, with no evidence of cyanosis or clubbing. Blood pressure was 120/70; P_2 was accentuated and markedly split, the split increasing on deep inspiration. A Grade II, harsh, medium-pitched systolic murmur was heard in the 2d and 3d intercostal space and was transmitted to the back. Cardiac catheterization data are given in Table I. The angiograms disclosed pulmonary coarctation mainly on the left, less marked on the right side (Fig. 1).

The child was last seen in the hospital Aug. 6, 1958, and was doing well. Physical findings were unchanged and electrocardiograms again showed a right ventricular hypertrophy which appeared to have increased since the previous examination.

CASE II: A 17-year-old girl was admitted for observation and diagnosis on Oct. 14, 1958. The foster parents were told when they adopted the child at the age of three months that "her heart should be watched." Nothing was known about the mother's pregnancy or delivery. The patient recalled having some shortness of breath and dyspnea on exertion all her life and she avoided sports. She never was cyanotic and until recently she was able to maintain normal activity. During the last eight months her shortness of breath had become worse and she noticed some ankle swelling. While she was working as a dentist's assistant the swelling occurred in the late afternoon and disappeared overnight.

AUTHORS' CASES

Saturation: Area	Saturation: mm. Hg	Pressure: Area	Pressure: mm. Hg	Location of Stenosis	EKG	Comment	Case
MPA	68	MPA	48/9	Coarctation LPA; less marked in RPA	Right ventricle enlargement		I
RPA	70	RPA	39/10				
RV	68	RV	68/−2				
RA	68	Apex					
BrA	98						
MPA	69	MPA	38/10	RPA	Right ventricle enlargement		II
RPA	69	RPA	34/16				
RV	67	RV	48/0				
RA	69						
MPA before	71	MPA before	84/42	LPA	Combined hypertrophy with P pulmonale	IV shunt	III
AC after	71	AC after	64/14				
RV	65	RV	92/0				
RA	48						
6-7-58		6-7-58		Scodaic coarctation, 6-16-56	Right ventricle enlargement	IA, IV shunt. Corrected transposition	IV
RA	70	RA	12/0				
RV	72	RV	65/0				
6-16-56		6-16-56			Right ventricle enlargement, 6-12-56		
RV	88	RV	100/0				
RA	71	RA	4/0				
IVC	59	LA	4/0				
SVC	59						
LA	94						
RV	61	RV	72/0	RPA	Right ventricle enlargement; right bundle branch block		V
RA	70	RA	10/8				
FA	97						
RA	46	RV	84/3	Right and left pulmonary artery, new branches	Right ventricle enlargement	IA and IV shunt; infundibular and pulmonary stenosis	VI
RV	43	LV	87/3				
LV	76						
RV	56	RV	120/47	Left and right pulmonary artery near branches more pronounced on left	Right ventricle hypertrophy		VII
RA	56	RA	11/3				
FA	94						

The patient's past history revealed the usual childhood diseases and recurrent chest pain. On physical examination she appeared to be well nourished and well developed. There was no evidence of cyanosis or clubbing. Pulmonary function studies were normal. On heart examination, a Grade IV precordium murmur was noted, maximal over the pulmonic area, transmitted toward the neck and the back, with a marked accentuation of P_2. A thrill was felt over the 2d left intercostal space. The electrocardiogram was consistent with right ventricular hypertrophy. Cardiac catheterization and angiocardiography demonstrated pulmonary coarctation (Fig. 2). The catheterization data are seen in the table. After these studies, a similar less prominent murmur was noted on the right.

CASE III: A weak appearing white male child was born on March 10, 1958. The pregnancy and delivery were uneventful. The child weighed 3 3/4 pounds, was blue at birth, and was kept in an oxygen tent until Sept. 20. On examination in this hospital on Oct. 17, the infant appeared small and undernourished. He was in acute distress and had a rapid respiratory rate, cough, and slight rib retraction. He was not cyanotic and there was no clubbing. A left precordial bulge was noted. A Grade IV, harsh blowing systolic murmur was heard over the entire precordium, maximal in the 3d left intercostal space. P_2 was markedly accentuated. The electrocardiogram showed a combined hypertrophy with a P pulmonale. Heart catheterization was performed on Oct. 22, and the data are given in the table. The impression was interventricular septal defect and pulmonary coarctation.

CASE IV: A child born on Nov. 26, 1951, after a full-term normal pregnancy was first seen in this hospital on Nov. 20, 1953. The birth weight was 6 pounds, 11 1/2 ounces. The infant appeared blue shortly after birth, and a murmur was heard on the third day. The neonatal period was otherwise normal. The child weighed 18 pounds at one year and 26 pounds at two years. She appeared to tire more easily than other children in the family, and the parents had noticed some dyspnea on exertion. Cyanosis varied from day to day but was never very marked. The general development was good and there was no evidence of heart failure.

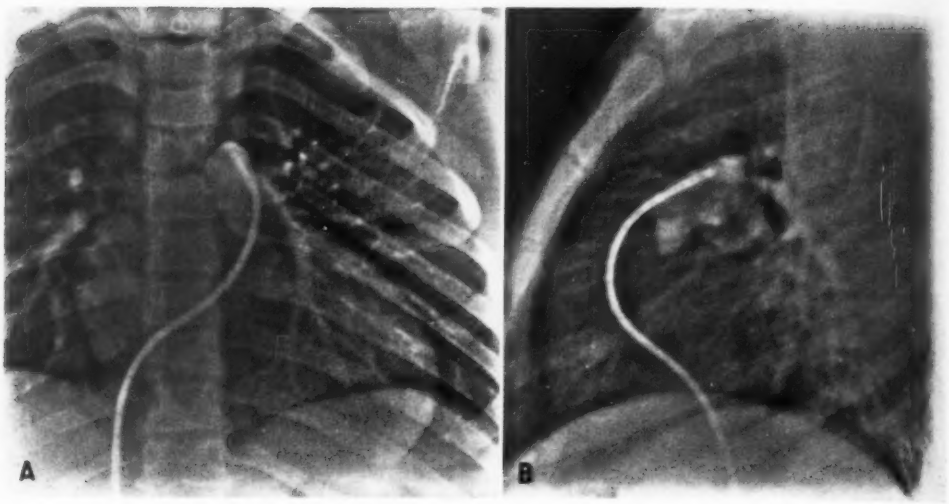

Fig. 1. Case I. Pulmonary coarctation, more marked on the left.

Physical examination revealed a mild cyanosis and 1 + clubbing of the fingers. An apical impulse was felt in the 4th left interspace in the midclavicular line, with a systolic thrill. A harsh, long Grade III systolic murmur was audible in the 2d and 3d left interspace, moderately well transmitted up toward the left clavicle. The second sounds were loud and clear. The electrocardiogram revealed a rather marked right axis deviation with a tall P wave in lead 2. The impression at this time was that the child had a single ventricle with pulmonary stenosis.

On Nov. 9, 1954, dyspnea had increased and cyanosis appeared more pronounced. Heart catheterization was performed June 7, 1955. The diagnosis now was interatrial septal defect with right-to-left shunt and right ventricular hypertension.

On June 16, 1956, the patient was readmitted for a second heart catheterization. During the presurgical examination she was found to be slightly cyanotic at rest but in no distress. Blood pressure was 70/50. Grade II clubbing of the fingers was noted. A Grade IV harsh systolic murmur was heard over the precordium, loudest at the 3d left intercostal space, associated with a thrill in that area. The point of maximal impulse was in the anterior axillary line. A_2 was greater than P_2 at this time. The catheterization data are presented in Table I. The final diagnosis, after angiocardiography (Fig. 3), was interatrial septal defect, interventricular septal defect, transposition of the great vessels (self-corrected), and coarctation of the pulmonary artery.

CASE V: D. S., a normal appearing white male, was born May 9, 1956, following an uneventful pregnancy. He was somewhat slow in development and his mother thought that he was sometimes "a little blue around the mouth." On physical examination a congenital cataract was noted in the left eye but the child was otherwise well developed and well nourished. A Grade III harsh systolic murmur was found over the pulmonic area radiating to the back. Electrocardiography and vectorcardiography showed a high degree of right ventricular hypertrophy. The pulmonary vessels were inconspicuous radiographically. For these reasons the child was called back on June 12, 1957, for heart catheterization and angiography. Catheterization data are presented in Table I. Angiograms showed the characteristic changes of bilateral main branch pulmonary artery coarctation.

CASE VI: A 2-year-old child had been born following a pregnancy complicated by a kidney infection during the first six weeks. Delivery was by cesarean section because slowing of the fetal heart sounds was noted and bleeding developed during the last three days of pregnancy. The birth weight was 4.12 pounds. The child was in oxygen from delivery up to two months of age. Later the parents noted cyanosis when the baby cried. Physical examination showed blood pressure of 90/60, pulse rate 130, and clubbing of fingers and toes. The skull was asymmetrical, being somewhat smaller on the left side. Over the heart a Grade I to II blowing systolic murmur was heard in the 2d and 3d left intercostal space. P_2 was greater than A_2. The electrocardiogram showed a right ventricular hypertrophy.

Half a year later the child was re-examined and was found to be cyanotic at rest, with a harsh Grade II systolic murmur and increased P_2. On the electrocardiogram the right ventricular hypertrophy appeared to be more marked. Catheterization showed an interatrial septal defect, interventricular

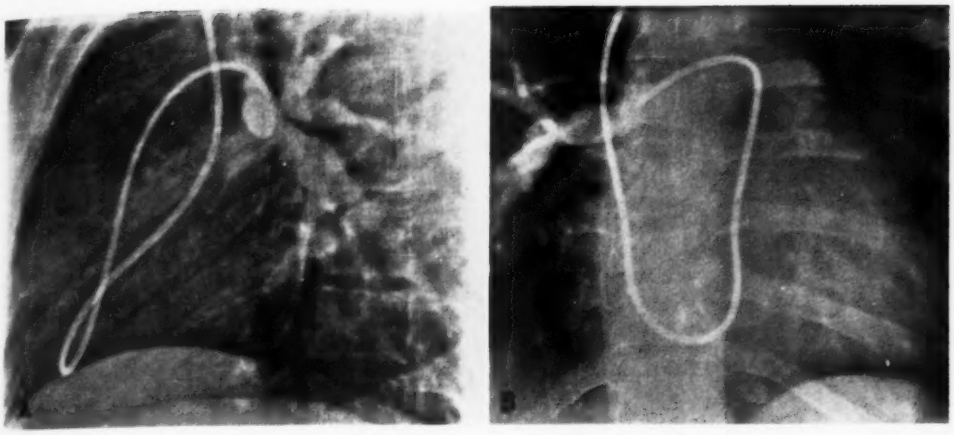

Fig. 2. Case II. Coarctation of the right pulmonary artery with post-stenotic dilatation. No other evidence of abnormality on catheterization or angiogram.

septal defect, and infundibular and pulmonary stenosis, with formation of a third ventricle. There was an enlarged redundant aorta. The pulmonary arteries were found to be narrowed near their points of branching, with poststenotic dilatations of the branches on both sides.

CASE VII: A 9-week-old white girl was seen with progressive tachypnea and tachycardia since shortly after birth. The prenatal, neonatal, and natal courses were uncomplicated. Three weeks prior to the examination, fever, cyanosis, and severe respiratory distress developed. It was thought that the child was in failure and digitalization was started two weeks before admission. This was completed in one week and there appeared to be definite improvement. On examination, the liver was found to be enlarged. A Grade IV blowing systolic murmur was heard all over the precordium, radiating into the back, with its maximal point in the 4th left intercostal space. There was accentuation of P_2, which was slightly split. A palpable thrill at the lower left sternal border was present. The electrocardiogram was consistent with a right ventricular enlargement and abnormalities of the right atrium. Heart catheterization did not show any evidence of a shunt but revealed a rather high pressure in the right heart and pulmonary stenosis at the distal end of both pulmonary arteries near their branches. The changes were more marked on the left than on the right side, with poststenotic dilatation of the branches of each of the pulmonary arteries.

EXPERIMENTAL STUDIES

From previous work (44) and from a review of the literature on pulmonary resection (36, 37, 39, 50), it is evident that removal of one entire branch of the pulmonary artery from the lesser circulation does not ordinarily cause pulmonary hypertension. The exceptions are so rare as to be reportable complications of pneumonectomy. Only 3 such cases were reported from the thousands of pneumonectomies performed during the last three years. Madoff (39), Roh (50), Soderholm (31), and Nordenstrom found no consistent or persistent elevation of pulmonary artery pressure following complete occlusion of a main branch of the pulmonary artery. Goldblatt's experiments on the renal circulation suggested that this could happen in the lung and also suggested that partial pulmonary arterial occlusion might have a different effect (21). In order to produce optimal partial occlusion, the following experiment was devised.

A snug, nonconstricting silk ligature was placed about the left branch of the pulmonary artery about 0.5 to 1.0 cm. from the bifurcation of the main pulmonary artery of each of 21 puppies, four to six weeks of age, weighing approximately 4 kg. each. Pentothal anesthesia and endotracheal I.P.P. oxygen permitted an intrapericardial approach to the left pulmonary artery. Ten puppies survived this procedure. In 2 the silk ligature was removed before closure of the chest. In 2 others the ligature was pulled tightly, to produce complete occlusion of the left pulmonary artery (Fig. 4).[2]

At varying intervals these puppies were then

[2] One of each of these puppies died before completion of the experiment. Six others died postoperatively before surgical technics were standardized.

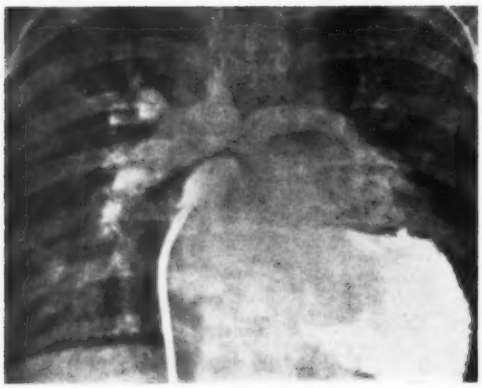

Fig. 3. Case IV. Central or scodaic coarctation at the bifurcation of the pulmonary artery. This child also had atrial and ventricular septal defects and transposition of the great vessels (self-corrected).

allowed to grow up around the silk ligature, as we believe children grow up around coarctations of the aorta (43). The dogs were kept in standard cages and gave no sign of fatigability, shortness of breath, or dyspnea. Regular kennel diet was used. An epidemic respiratory and gastrointestinal disease contributed to the deaths of 11 young puppies in a room and in cages previously occupied by cats. Some were thought to have had acute cor pulmonale in addition (Fig. 5).

The experimental findings appear to bear out our clinical observations regarding the relationship in question between pulmonary artery coarctation and pulmonary hypertension.

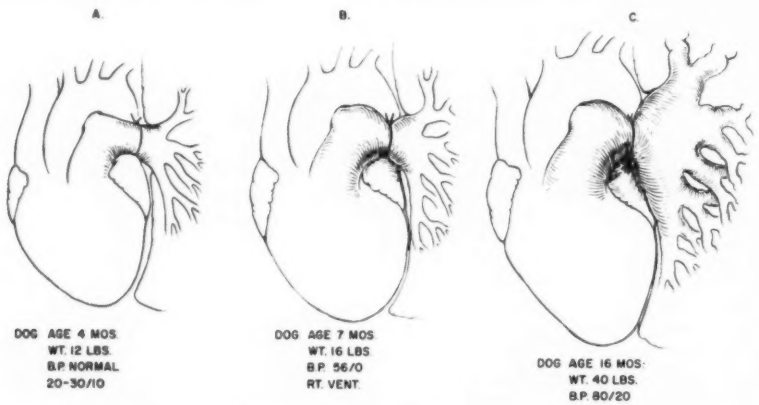

Fig. 4. Experimental production of pulmonary artery occlusion.

studied by means of right ventricular and pulmonary artery pressure tracings and by angiocardiography. A light pentothal anesthetic was used for these procedures. Table II shows the results of these and other studies.

An inspection of the tabulated results of the experiments shows a fairly clear relationship between blood pressures in the right ventricle and in the pulmonary artery and the time in months after the dog had been operated upon. Two exceptions to this general statement are noticeable; dog 10, upon which an operation was done but no silk tie left around the left pulmonary artery, and dog 8, in which the silk tie was pulled tight, occluding the artery at that site. Each of the other animals was

HISTORICAL STUDIES

Partial atresia of the main branches of the pulmonary artery was first reported by Oppenheimer in 1938. Søndergaard (1954) suggested the term coarctation because of the apparent connection between the central constriction of the artery in his case with the closing ductus arteriosus (scodaic theory). Other case reports appeared soon thereafter and are listed in Table III in order of occurrence.

Eldridge (1957) produced this lesion in a dog and noted the characteristic murmur. He concluded that pulmonary artery coarctation was a benign disease of no prognostic, therapeutic, or surgical interest (4).

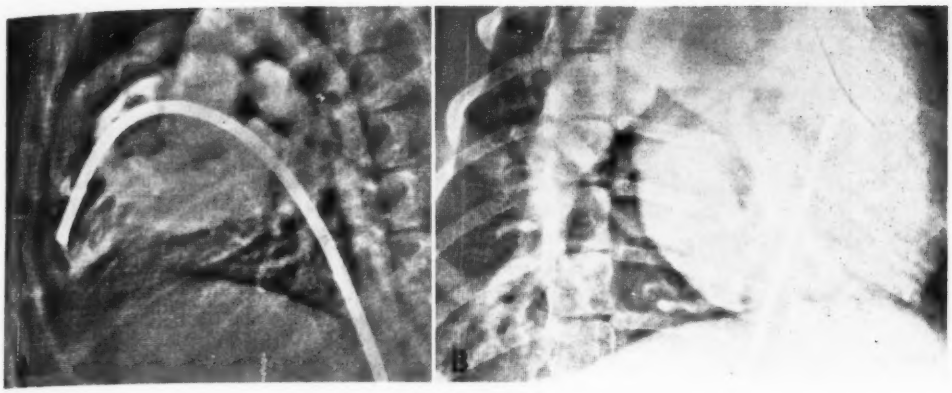

Fig. 5. Experimental study.

Figley in 1956 and Van Epps in 1957 reported the radiologic findings in peripheral pulmonary artery coarctation. None of the previous authors derived a causal relationship between the coarctation and elevation of the blood pressure in the pulmonary circulation.

pulmonary vascular bed. Many of these associated lesions in themselves are enough to raise the blood pressure without the addition of coarctation of the pulmonary artery. Nevertheless, since the combination of coarctation and hypertension can occur independently, the accident of associated lesions should not detract from the significance of the observation.

TABLE II: RELATIONSHIP OF BLOOD PRESSURE IN THE LESSER CIRCULATION TO THE TIME IN MONTHS AFTER OPERATION UPON THE LEFT PULMONARY ARTERY

	Puppies	Weight (lb.)	Months after Operation	Right Ventricular Pressure	Main Pulmonary Artery Pressure	Right Pulmonary Artery Pressure
10	Charlie	10	0.0	30/0*	10/6	...
4	George	7	0.5	40/0	...	28/22
1	John	10	1.0	44/0	...	34/28
2	Leo	15	2.0	48/0	...	...
3	Ross	16	3.0	55/12	42/28	40/22
6	Wilhelm	30	7.0	120/0	...	...
5	Fred	36	7.0	80/0	...	...
7	Benjamin	26	10.0	60/0	46/22	38/20
9	Don	40	12.0	80/0	80/20	...
8	Paul	21	5.0	30/0†	30/12	22/8

* The silk ligature was removed from No. 10 immediately after application.
† No. 8 was ligated tightly, completely occluding the left pulmonary artery. All others had an operation on the left pulmonary artery at the age of five weeks except No. 9, which was four months old at time of surgery. Note elevation of right ventricular and pulmonary artery pressures.

Children who have pulmonary artery coarctation frequently have associated cardiovascular defects as well as other somatic anomalies. The one most often noted is valvular pulmonary stenosis. A characteristic step-like elevation of the pulmonary artery pressure is seen on withdrawal of the catheter through the stenotic areas. Lesions which increase pulmonic flow are also sometimes associated, and the findings of transient constrictions makes one think of a self-imposed Damman-Muller procedure protecting the

Systolic murmurs over the site of coarctation occur so often as to be characteristic. Thrills and diastolic murmurs are less frequent but are compatible with the diagnosis. Some children have been operated upon for patent ductus arteriosus because of such murmurs and thrills (14). Pulmonary artery coarctation must be included in the differential diagnosis for patent ductus.

Comments on Table III: Review of the

TABLE III: CASES FROM THE LITERATURE

Author and Case No.	History	Murmur	Thrill	P_2	Pressure Area	Pressure mm. Hg	Location of Stenosis	Shunt
C. B. Williams (60)								
No. 1: 15-yr.-old male	Low height and weight; easy fatigue; frequent upper respiratory tract infections; deaf mute; long digits; exertional dyspnea	Harsh systolic in 2d & 3d left intercostal space	Systolic	Greater than A_2	RV PA	64/0 31/0	Hypoplastic pulmonary artery on one side	None
No. 2: 4½-yr.-old	Heart murmur since birth; small size; cyanosis; easy tiring; squatting	Loud systolic blowing, left 3d intercostal space	None	A_2 greater than P_2	PA RV RA	5/2 80/0 2/0	Pulmonary artery near bifurcation	None
	.....				.....	.....		
	Postoperative for pulmonary valve stenosis				RV PA	100/0 50/18		
No. 3: 11-yr. old female	Heart murmur since 3 yr. old. Frequent respiratory infections; slight prominence of left chest wall	Loud systolic in 2d intercostal space	Systolic, left sternal border	A_2 greater than P_2	PA Distal MPA RV RA	26/11 33/11 55/0 12/1	Post. valvular stenosis in main pulmonary artery	IVS
No. 4: 4-yr.-old male	Murmur since 2½ yr. Decreased exercise tolerance; easy tiredness; circumoral blueness when cold	Harsh systolic, short diastolic, murmur over apex	Systolic, apical	P_2 split	PA Distal MPA RV	22/6 27/6 34/0	Post. valvular stenosis in main pulmonary artery	IA IV
Søndergaard (55)								
No. 1: 4-yr.-old male	Severe tetralogy of Fallot	Continuous murmur	...	...	...	...	Scodaic stenosis	Tetralogy
No. 2: 10-mo.-old male	Cyanosis with dyspnea since birth	...	...	...	...	...	Constriction right, left, and main pulmonary artery at bifurcation	Pulmonary valve stenosis
No. 3: 29-yr.-old female	Palpitation; shortness of breath on exercise. Cyanosis for 1 yr. prior to examination	...	...	.	RV	150	Right and left pulmonary artery and main pulmonary artery	Pulmonary valve stenosis IA
T. A. Möller (41)								
No. 1: 15-yr.-old female	Dyspnea at 2 yr. Palpitation on exertion. Cardiac enlargement since 6 yr.	Continuous murmur above aortic area	...	...	RV PA	Hypertension 78/31	Multiple peripheral coarctation	Aortic window
J. E. Coles (6)								
No. 1: 26-mo.-old female	Heart murmur since birth; poor appetite; decreased exercise tolerance	Grade IV systolic murmur in pulmonic area	Systolic	A_2 greater than P_2	RPA Distal MPA	15/5 50/8	Narrowing of initial portion of both pulmonary arteries	Patent foramen ovale
J. Arvidsson (2)								
No. 1: 15-yr.-old female	Physically and mentally underdeveloped. Impaired vision since 11 yr.	Continuous systolic and diastolic murmur over entire chest	...	...	PA RV	78/31 78/0	Peripheral arteriostenosis	Patent ductus
No. 2: 19-yr.-old female	Normal development until 10 yr. After that, shortness	High-pitched systolic at apex. Long harsh systolic at base, trans-	...	...	MPA	65/13	Multiple peripheral stenosis	MPA

No. 2: 19-yr.-old female	Normal development until 10 yr. After that, shortness of breath	High-pitched systolic at apex. Long harsh systolic at base, transmitted to carotid	...	...	MPA	65/13	Multiple peripheral stenosis	MPA
No. 3: 33-yr.-old female	Congenital heart disease noted since early precordial pain	Grade III systolic over entire heart transmitted to back	...	...	PA	72/7	Multiple peripheral coarctation	IA
No. 4: 10-yr.-old male	Heart disease since early childhood. Cyanosis	Coarse systolic in 2d intercostal space	...	...	MPA	108/22	Multiple peripheral stenosis	...
E. F. Van Epps (58) No. 1: 6-yr.-old male	Murmur since 4 yr. Repeated upper respiratory infections. Easy fatigue; dyspnea; liver enlargement; hemoptysis	Grade II systolic, in left 2d and 3d intercostal spaces, radiating to axilla, neck, and apex	...	...	RV PA Distal PA	95–110 / 0–2 88–108 / 14 8–12 / 2–4	? Multiple aneurysms	Small patent foramen ovale
No. 2: 4-yr.-old male (brother of preceding)	Squatting; murmur noted at 4 yr.	Grades II–III harsh systolic murmur in pulmonary area	Systolic in neck vessels	P_2 split	RV MPA Distal PA	58/9 58/10 15/0	Multiple peripheral stenosis	...
J. Dighiero (11) No. 1: 17-yr.-old girl	No symptoms except slight shortness of breath after physical exercise	Systolic Grade IV murmur in 2d and 3d intercostal spaces and all over chest	Intercostal systolic in 3d and 4th left intercostal spaces	...	RV PA	107 55	Multiple peripheral stenosis	...

cases gleaned from the literature and comparison with our own show certain similarities in histories and in the physical findings. Part of the children were somewhat retarded developmentally, while many had associated anomalies. Ease of fatigue and dyspnea were noted in several instances and were what usually brought the child to the doctor. Where associated lesions were present, cyanosis was a prominent finding, probably because of reversal of shunt with effort. No characteristic familial history or history of illness in pregnancy could be elicited.

Patients with only pulmonary coarctation usually had no complaints and were examined because of a murmur heard during a routine examination. Apparently, after a long period of feeling well, symptoms of easy fatigability and dyspnea on exertion occur, as in our oldest patient (No. 2). The murmur is characteristically a systolic one in the 2d and 3d intercostal spaces, radiating into the back of the neck.

A thrill was present in over one-half of these patients. In some the heart was enlarged. In the presence of associated intracardiac defects, other murmurs were frequently present. The electrocardiogram invariably showed right ventricular hypertrophy. Where more than one observation was possible, this could be seen to be of increasing severity with the passage of time. In one instance, relief of pulmonic stenosis elevated the right ventricular pressure and increased the right ventricular hypertrophy manifested by the electrocardiogram, all presumably due to accentuation of the relative ischemia of the lung distal to the coarctation. Since pulmonic stenosis was so frequently associated with pulmonary artery coarctation, the pulmonic second sound was frequently reduced or split. In those instances where the pulmonic valve was normal, however, the pulmonary second sound was accentuated and was louder than the aortic.

Roentgenograms prior to the more definitive radiological studies usually showed changes consistent with right ventricular

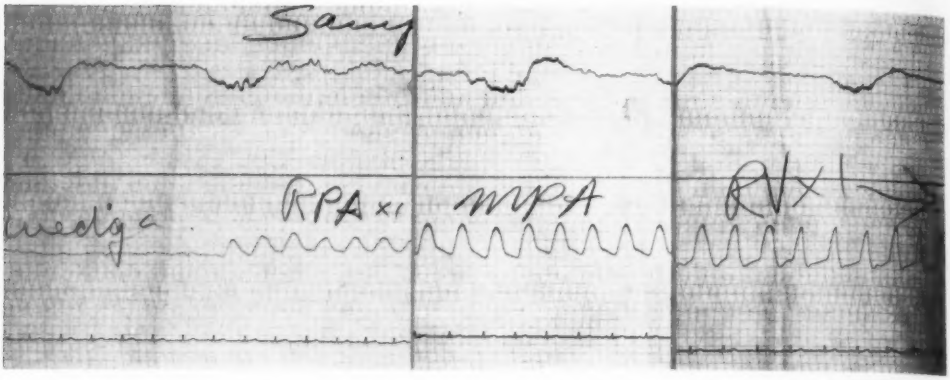

Fig. 6. Case II. Pressure tracing from the catheter tip as it is pulled back from being wedged in the distal pulmonary arteriole. Note the abrupt change in pressure between the RPA (right pulmonary artery) and the MPA (main pulmonary artery). This is the site of the coarctation. Changes on relief of "wedging" and on passage through the pulmonic valve are within normal limits.

enlargement. Frequently there was prominence of the pulmonic segment, and, where one or the other artery was involved, it was usually rather inconspicuous. In many instances the opposite artery was enlarged.

The most characteristic finding at heart catheterization was the "step-up" in pressure which occurred as one passed each coarcted segment (Fig. 6). Other less specific changes were the general increase in pressure which was observed in the main pulmonary artery and in the right ventricle. In uncomplicated cases, oxygen saturation was at the lower limits of the normal range. Where other defects occurred in association with pulmonary artery coarctation, the characteristic findings were added to those of the arterial constrictions. Where angiocardiographic studies were available, these proved to be most helpful in delineating the nature, extent, and number of the lesions in the pulmonary arterial system.

Although we have not advocated surgery for this condition, many patients have been operated upon for the associated defects and some have been operated upon because of misinterpretation of the murmurs which were found. In these, of course, direct observation of constricted pulmonary arterial segments has offered a fairly conclusive diagnosis.

DISCUSSION

Since cholinergic drugs are reported to relax arteriolar muscle spasm, pulmonary hypertension due to hypertonicity of the media of the pulmonary artery can be expected to respond to acetylcholine or adrenalin. When fresh acetylcholine is injected into the pulmonary artery of children with hypertension due to an interventricular septal defect there is a prompt drop in blood pressure in the lesser circulation in most instances (8). In three experiments on animals, however, we failed to observe this phenomenon. In one dog two weeks after ligation acetylcholine injected into the right ventricular cavity showed no effect, indicating that a paradoxical reaction to acetylcholine was already present. In another dog, twelve months after operation for production of pulmonary hypertension, acetylcholine caused an elevation from 80 to 170 mm. Hg (Fig. 7) in the right ventricle rather than the expected drop in pressure, and subsequent intraventricular injection of Priscoline produced no effect. In a third dog, three months after the operation, acetylcholine caused a rise from 42 mm. Hg to 70 mm. systolic in the pulmonary artery. Injection of adrenalin after completion of this study and after return of the pressure to the normal level of 42 again led to an elevation to 90 mm. Hg in the pulmonary artery. A normal periph-

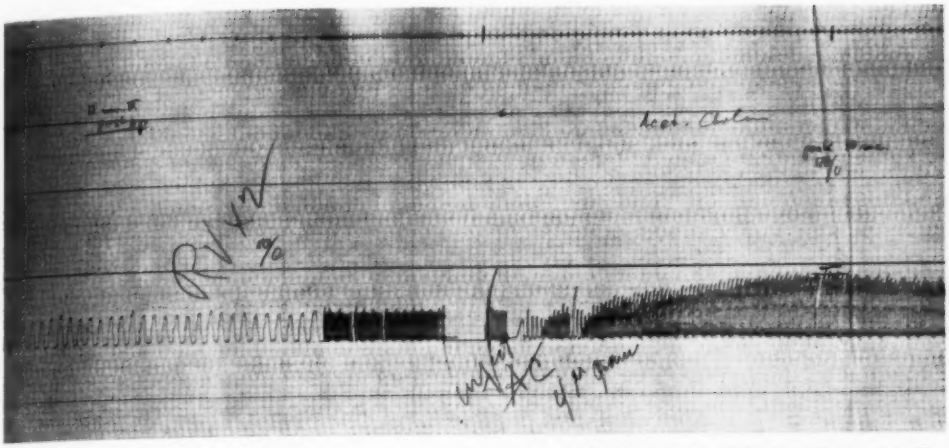

Fig. 7. Dog No. 9. Right ventricular pressure tracing before and following the injection of acetylcholine (4 mg./kg.). The spread of the recording paper is indicated on the top line. Each perpendicular mark indicates one second.

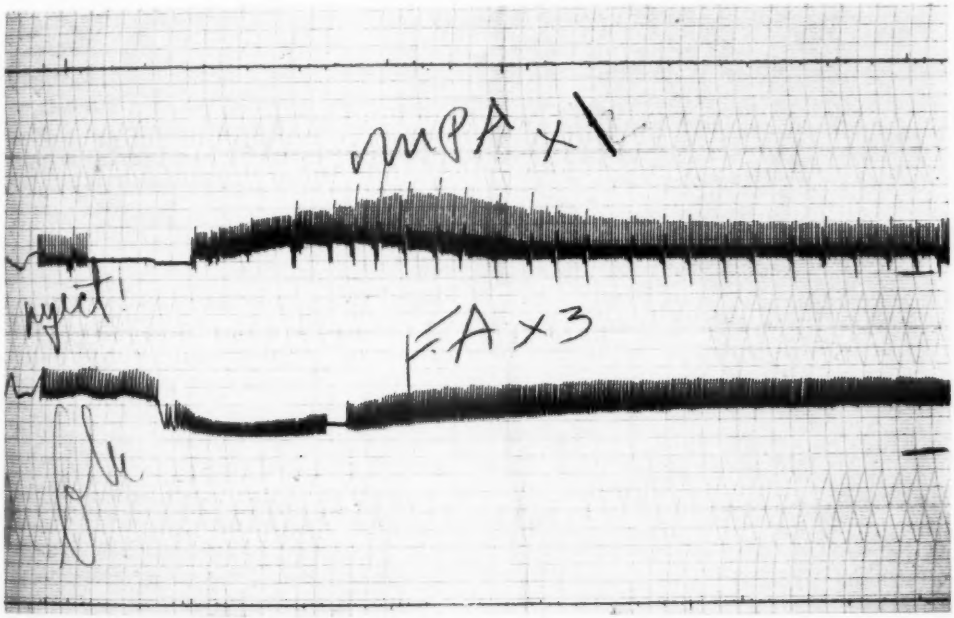

Fig. 8. The peripheral reaction to acetylcholine is shown here as a normal drop in arterial pressure, while at the same time the pressure in the main pulmonary artery rises paradoxically.

eral systemic reaction to acetylcholine injection occurs simultaneously (Fig. 8). Another preparation, a Burroughs Wellcome experimental cholinergic, also gave no drop in blood pressure on instillation into the pulmonary artery or right ventricle.

Anatomical considerations do not suggest a strong basis for the development of the hypertension observed. The pulmonary arteries contain less muscle tissue but more elastic connective tissue than do other arteries in the peripheral circulation.

The muscle fibers are oblique. It is said that muscular contraction does not lead to a narrowing of the vessels but only to a shortening of all the pulmonary arteries down to those of 1 mm. diameter (52). Some of our angiograms, however, demonstrated a transient narrowing. Arterioles and precapillaries here are wider than their counterparts in the peripheral circulation. These and the pulmonary capillaries may form a reservoir influenced by the contractility of the pulmonary veins, which can contract and thus regulate venous return to the heart. The bronchial arteries of the peripheral circulation supply each bronchus with several branches, while only one branch of the pulmonary artery accompanies each bronchus. Anastomoses between the pulmonary arteries and bronchial arteries are ever present and under some certain circumstances become quite profuse. For instance if the pulmonary artery is tied, its peripheral branches may remain open because of the anastomosis with the bronchial arteries. The pulmonary circulation then has its own control mechanism, which is independent to a large degree of the factors regulating right and left heart flow. Venous return is not necessarily equal to pulmonary arterial inflow into the lung.

Some pressor reflexes come over the vagus and some come over the sympathetic trunks. The blood volume is also regulated neurogenically, but in a more passive manner, by the action of the diaphragm and other respiratory muscles affecting intrathoracic pressure. Peripheral pulmonary vasoconstriction does not ordinarily occur with increase in pressure within the pulmonary arteries, but this may occur when pressure is increased by a factor of 4 or 5 or more, to protect the capillaries from excessive arterial pressure.

When the lung is denervated in the face of an increase in pressure, pulmonary edema usually ensues (17). An excess of oxygen in the inspired air tends to reduce pulmonary artery pressures. Anoxia has the opposite effect. Cournand reduced oxygenation of one lung by bronchospirometric methods and observed an increase in pulmonary arterial pressure which he attributed to a shift in volume of blood from the systemic to the pulmonary vascular bed. Anoxia, too, may lead to pulmonary edema. Viscosity of the blood is related to oxygenation as well as to the pulmonary arterial pressure necessary to move it through the vessels (4). An increase in circulating blood volume can also contribute to an increase in pulmonary arterial pressure.

Pulmonary hypertension has been produced in dogs by anastomosing the subclavian artery to the pulmonary artery and by increasing venous resistance by ligation of pulmonary veins and/or the left atrium (17, 19). Within two weeks medial hypertrophy was found which was demonstrated quite dramatically by Verhoeff-van Gieson stains. In two to three months intimal proliferation was identified, proceeding in some cases even to obliteration of the lumen of the vessels. Intimal proliferation is most prominent at the bifurcation of the vessels, as is the medial hypertrophy, and here a sort of "pruning" effect is noted, which is demonstrable on microradiographs as well as on the cut sections of the lung. Short found a varying picture in pulmonary hypertension related more or less directly to the severity, duration, and etiology of the disease (54).

Other attempts have been made to produce pulmonary hypertension experimentally, many of them in association with studies on pulmonary embolus. Particles of different sizes have been freed in the pulmonary circulation, affecting the arteries in the order of size and irritant qualities. Paraffin, fibrin clots, blood clots, podophyllin, and silver nitrate have all been used in this way. Although transient pulmonary hypertension has been observed, reflex constriction of the pulmonary vessels due to such embolization has never been conclusively demonstrated (29, 33).

Fibrin clots introduced into the pulmonary circulation caused partial obstruction of the pulmonary artery and an in-

crease in pulmonary artery pressure until the clot was absorbed. With absorption, the pressure returned to normal (37). Krall and Nordenstrom have blocked one pulmonary artery with a balloon. A transitory increase in pulmonary artery pressure ensued where the blockage was incomplete. With complete occlusion of the vessel the pressure gradually descended to the level where it had been prior to occlusion. In either event, after removal of the balloon blocking the flow through the vessel, the pressures quickly returned to normal. Nordenstrom demonstrated an increased flow through the bronchial arteries during this type of occlusion, as well as a depression in circulation time through the occluded lung. Presumably the blood content of the nonoccluded lung increased comparably.

Ligation of one of the pulmonary arteries results in a sharp increase in the amount of blood circulating through the bronchial arteries (36), which tended to fill the pulmonary arteries in a retrograde fashion. This increase in broncho-arterial flow can account for more than a third of the circulating blood volume and is effectively a left-to-right shunt. No increase in pulmonary arterial pressure or in right ventricular pressure is noted in these instances. When, however, the pulmonary artery coarctation is not complete, the pressure does go up. From these discussions, from the review of previously reported cases of patients with coarctation of the pulmonary artery, and from our own clinical and experimental studies no clear-cut explanation on a mechanical or neurogenic basis becomes apparent. The most likely explanation for the phenomenon observed is suggested by the work of Goldblatt (22) and of Cournand (7). Hypoxia or ischemia of the lung may stimulate the right ventricle to increase pressure proportionately to the pulmonary artery coarctation, or the ischemic lung may liberate a hormonal substance which has the same effect.

SUMMARY

Seven new cases of pulmonary arterial coarctation are reported, bringing the total number in the world's literature to 23.

The 16 previously reported cases are reviewed and tabulated.

Pulmonary arterial constrictions are invariably associated with elevation of the blood pressure in the lesser circulation. Three types of constriction have been identified radiologically: central (or scodaic), main branch, and peripheral. The etiology of the three types is probably different but the manifestations (hypertension) are the same. These lesions frequently complicate pulmonary valvular stenosis.

While one might think of this constriction as a hypertonic response to elevations in pressure, experimental evidence does not support such a concept. Experimentally produced pulmonary artery coarctation *causes* pulmonary hypertension. The exact mechanism has not been established, but it appears to be related to pulmonary ischemia.

The disease is clinically significant and can be diagnosed radiologically.

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SUMMARIO IN INTERLINGUA

Hypertension Pulmonar Causate per Coarctation Pulmono-Arterial

Es reportate septe nove casos de coarctation pulmono-arterial, portante le total del casos reportate in le litteratura mundial a 23. Le 16 previemente reportate casos es passate in revista e tabulate.

Constrictiones pulmono-arterial es invariabilemente associate con elevation del tension de sanguine in le circulation minor. Tres typos de constriction ha essite identificate radiologicamente. Illos es (1) central o skodaic, (2) del branca principal, e (3) peripheric. Le etiologia del tres typos es probabilemente differente, sed le manifestationes, le hypertension, es le mesme. Iste lesiones es frequentemente complicationes de stenosis pulmono-valvular.

Il es natural voler interpretar iste constriction como un responsa hypertonic al elevation del tension de sanguine, sed le datos experimental non supporta iste idea. Quando coarctation pulmono-arterial es producite experimentalmente, illo *causa* hypertension pulmonar. Le precise mechanismo ha non ancora essite establite, sed illo pare esser relationate a ischemia pulmonar.

Le morbo es clinicamente significative e pote esser diagnosticate radiologicamente.

DISCUSSION

(Papers by Bell, Shimomura, Guthrie, Hempel, Fitzpatrick, and Begg; Falkenbach, Zheutlin, Dowdy, and O'Loughlin)

Paul Kezdi, M.D. (Chicago, Ill.): I first became acquainted with the problem of coarctation of the pulmonary artery when, in 1956, we operated on an eight-year-old boy with to-and-fro murmur for patent ductus. At surgery, the ductus was found to be closed. The surgeon observed a narrowing of the right pulmonary artery. Subsequent cardiac catheterization proved a pressure gradient between the right and main pulmonary arteries and excluded any intracardiac defect. There was only a mild pulmonary hypertension, the pressure being in the main pulmonary artery 35/15 mm. Hg, and in the right ventricle 35/2. In the right pulmonary artery beyond the narrowing, the pressure was 16/7. No further studies were performed and the patient is under clinical observation.

Several reports of similar cases appeared in the literature since. The studies of Dr. Falkenbach and his associates, however, are far more important than the mere description of these anomalies, since their work might shed some light on the mechanism of pulmonary hypertension. The fact that complete obstruction of one pulmonary artery usually does not lead to pulmonary hypertension while partial

obstruction usually does so indicate that other than mere mechanical factors are involved.

It is possible that ischemia or hypoxia produced by partial obstruction of one of the pulmonary arteries results in some mechanism elevating vascular resistance in the rest of the pulmonary arterial tree. It is known that following obstruction of the pulmonary artery a bronchial artery shunt develops in the poststenotic section. It may be that complete obstruction leads to shunting of enough oxygenated blood to prevent this mechanism, while partial obstruction does not.

Dr. Falkenbach and co-workers have the merit of pointing to a new method of studying the mechanism of pulmonary hypertension. However, we are quite far from the solution of this problem and a lot has yet to be learned before we understand the mechanism of pulmonary hypertension.

Unilateral Pulmonary Embolism with Increased Compensatory Circulation Through the Unoccluded Lung

Roentgen Observations[1]

FELIX G. FLEISCHNER, M.D.

PULMONARY EMBOLISM, with or without infarction, is now recognized in life as well as at autopsy. Only recently, however, has the frequency of nonfatal embolism been appreciated. As awareness has increased, the diagnosis is more often made, in some hospitals ten times as frequently as only a few years ago. The recognition of an infarct, providing almost conclusive evidence of embolism, is the most important roentgen contribution to the diagnosis of pulmonary embolism. Less conclusive signs are pleural effusion, inhibited respiration, often accompanied by atelectasis, acute pulmonary edema, and the signs of acute and chronic cor pulmonale or pulmonary hypertension, including also roentgen evidence of the oligemic lung field and the plump hilar shadow (1–5).

An additional observation made in massive unilateral embolism is the subject of this report.

OBSERVATIONS

CASE I: A man aged 39 years was hospitalized for severe idiopathic ulcerative colitis. At that time, Feb. 8, 1956, a routine chest roentgenogram was normal (Fig. 1A). Two weeks later thrombophlebitis developed in the right foot and ankle. On March 16 a sudden sharp right chest pain occurred, with a dry cough. The roentgenogram showed gross changes (Fig. 1B). The right hilar shadow was plump and the bronchial interhilar-cardiac zone was obscured. The hilar shadow was less clearly articulate than before. The right lung field showed increased radiance. In the right upper and midlung fields the vascular shadows had almost completely disappeared; in the lower lung field there were narrower vessels, mostly veins. The left lung field contrasted with this right oligemia. The hilar vessels, well articulated, were widened, and dilated vessels were visible, mainly in the mid and lower lung fields, denoting pleonemia[2] of the left lung. The diaphragm on both sides was moderately elevated. The cardiac silhouette was dilated, measuring 14.0 cm. across the base, compared with an earlier measurement of 12.9 cm.; suggesting right ventricular dilatation.

No further embolic episode occurred under anticoagulant treatment. Five months later (Fig. 1C) the hilar shadows had returned to normal width and configuration. The right upper lung field still showed slightly increased radiance. Otherwise, however, the peripheral pulmonary vessels had returned to even and symmetrical width and distribution.

The comparison of the pre-embolic roentgenogram (Fig. 1A) with that at the height of the embolic episode (Fig. 1B), and another five months later (Fig. 1C), clearly reflects the pathologic sequence. In B an embolus had lodged in the right pulmonary artery. The mechanical obstruction and vasoconstriction of the peripheral arteries prevented blood flow to the right lung, which appeared oligemic. The right hilar shadow was increased in size, due either to the embolothrombus lodged there or to the pulmonary hypertension, or to both. At the same time the hilar vessels on the left were markedly widened, forming a plump hilar shadow. The individual larger vessels, mainly in the mid and lower lung fields, were dilated. The changes were most noticeable by the contrast between the right and left lung fields. With clinical recovery, the roentgenograms recorded resumption of blood flow to the right, and five months later the blood distribution and vascular tree were symmetrically restored.

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[1] From the Department of Radiology, Beth Israel Hospital and Harvard Medical School, Boston, Mass. Presented briefly at the meeting of the New England Cardiovascular Society Nov. 18, 1957, and again at the Ninth International Congress of Radiology, Munich, July 1959. Accepted for publication in September 1958.

[2] The word "pleonemia" was introduced in 1951 by Maurice Campbell (Brit. Heart J. **13**: 438, 1951; Lancet 2: 647, 1951). In contrast to oligemia, "pleonemia" indicates an excess of blood as compared with the average, but without the implication of functional impairment or other disease which is associated with "hyperemia."

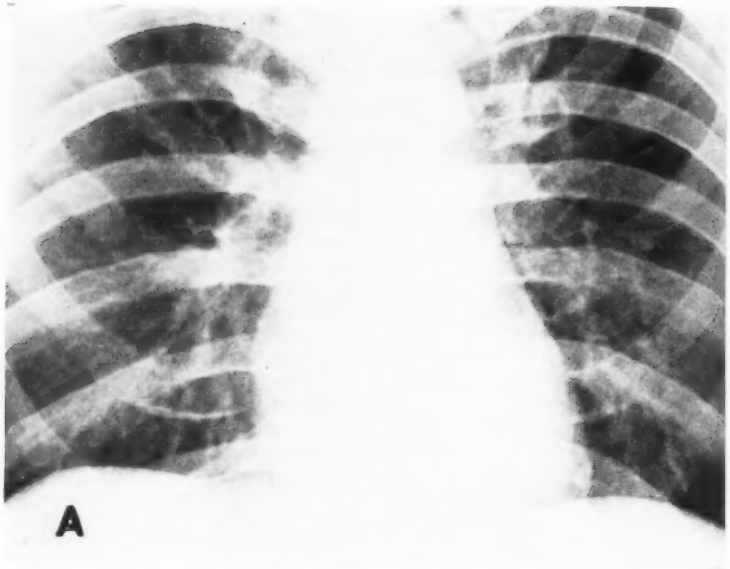

Fig. 1A. Case I. Feb. 8, 1956. The heart, lung fields, and vascular structures are normal.

CASE II: H. G. S., a 26-year-old man, had an episode of pulmonary embolism in June 1955, with an infarct in the right lower lobe and clinical and roentgen evidence of acute cor pulmonale, accompanied by thrombophlebitis. He recovered under anticoagulant treatment but had a relapse three months later[3], with another infarct on the right, and again recovered after bilateral femoral vein ligation and use of anticoagulants. Two roentgenograms (Fig. 2) are presented: one obtained on the first day of the disease (A), and one about two years later (B). In A the lung appears almost normal, with questionable slight haziness in the right lower lung field, where an infarct became distinctly visible four days later. The hilar vascular shadows, however, appear normal.

Two years later, with the patient in apparent health, the roentgenogram (B) shows gross changes. On the right the normal hilar vessels have markedly contracted or completely disappeared. Irregular small vessels are seen, possibly the branching bronchial artery. The entire right lung field shows scanty vascular markings and increased brightness (more prominent on the original film). In contrast, on the left the hilar shadow is plumper than before and the peripheral vessels, notably the arteries in the lower lung field, are much wider.

This young man had two severe pulmonary embolic episodes in rapid succession, with chest pain and infarcts on the right. It is a fair assumption that the embolization occurred mainly or exclusively to the right lung. Two years later one sees evidence of gross, possibly complete obstruction of the right pulmonary artery, manifested by oligemia of the right lung field. Irregular vascular structures, according to arrangement and general experience, apparently represent compensatory vascularization from the bronchial artery. All or almost all of the pulmonary arterial blood was diverted to the left lung and accommodated by the dilated vascular bed. Thus the vascular structures on the left appear wider, both the hilar and peripheral vessels, producing the picture of the pleonemic lung.

[3] For a detailed history of the acute stages of this case, see Fleischner (4), p. 667 and Figure 5.

DISCUSSION

Disturbances of the pulmonary circulation with diminished blood flow to one lung and increased flow to the other lung have been known in several morbid conditions, both congenital and acquired. In agenesis of the right or left pulmonary artery this condition can often be suspected

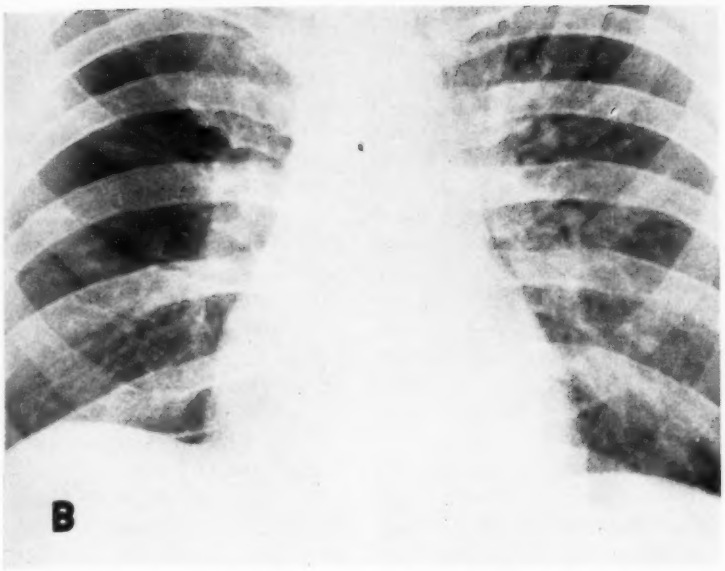

Fig. 1B. Case I. March 19, 1956. Three days after clinical onset of pulmonary embolism. The diaphragm is elevated on both sides. The right lung field shows marked oligemia: increased general brightness, and fewer and narrower vascular shadows. The right hilar shadow is plump. On the left: increased background fog and wider vascular shadows. The heart is slightly dilated (? right ventricle).

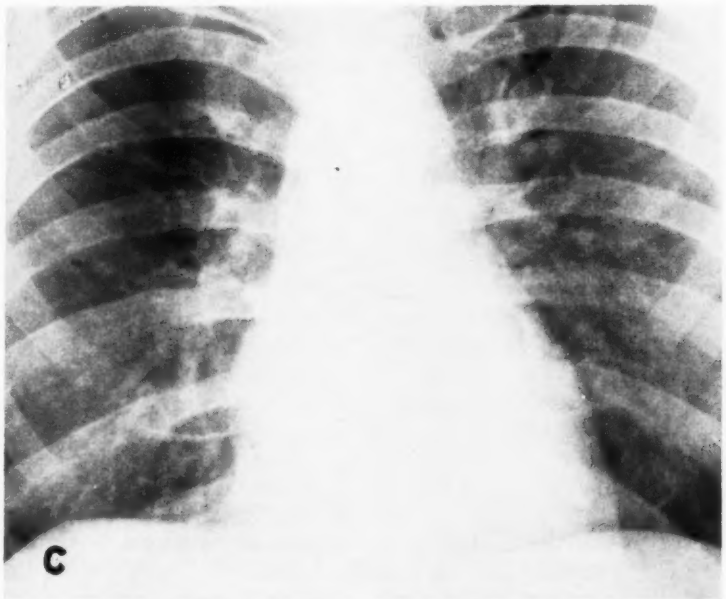

Fig. 1C. Case I. Aug. 16, 1956. Five months after Fig. 1B. The right lung field shows normal translucency except for residual slight increase in the upper lung field. The hilar and peripheral vascular structures have returned to normal appearance. There is no longer overfilling of the vascular bed on the left.

on the plain roentgenogram (6). Either the hilar shadow, normally made up of branches of the pulmonary artery and the upper veins, is smaller than usual, or entirely absent. In its stead one sees narrow and irregular vascular shadows which have been recognized as vicariously dilated bronchial arterial branches. In this congenital condition the involved hemithorax is smaller and the lung field is more translucent, oligemic. The angiocardiogram clearly reveals the abnormality: all the blood ejected from the right ventricle circulates through the unobstructed lung. The bronchial arteries, seen in the involved lung, fill at a later stage from the aorta.

Similar conditions, with complete or almost complete diversion of the pulmonary arterial blood to one lung, have been observed in unilateral tuberculosis, bronchiectasis, atelectatic fibrosis of any origin, with pneumothorax, and after pneumonectomy and thoracoplasty. In these instances one can hardly anticipate the circulatory disturbance from the plain roentgenogram because of the obscuring gross pulmonary and mediastinal changes (7, 8). It has been known particularly from the practice of therapeutic pneumothorax, but even more strikingly since the unilateral ligation of the pulmonary artery in the course of pneumonectomy, that the entire cardiac output can be shunted through one lung with little circulatory and respiratory disturbance. This is true, according to most investigators, only if the unoccluded lung is normal. If, however, the unoccluded lung is functionally damaged, particularly by diffuse emphysema or fibrosis, then its adaptability is reduced and the occlusion may cause a rise in pulmonary arterial pressure in the unoccluded lung, accompanied by a respiratory deficit.

This unilateral diversion of the blood has been studied also experimentally in animals and man with the use of the Carlens-Hanson-Nordenström balloon catheter (9). The catheter is passed from an antecubital vein through the right heart and positioned with its tip in the right or left pulmonary artery. By inflating the balloon one can completely occlude either primary branch of the pulmonary artery and the total right ventricular output perfuses the unoccluded lung. In a healthy subject the complete adjustment to this change occurs with amazing speed. Of the many interesting physiologic observations it may suffice to mention that the cardiac output remains unchanged. The velocity of the blood in the pulmonary vessels increases, and about twice the usual flow per minute passes the unoccluded lung.

This complete unilateral interruption of the pulmonary arterial circulation, occasionally observed with massive embolothrombosis has formerly caused discussions centered about the viability of such a lung (10). It is now fully understood that the nutrient blood supply provided by the bronchial circulation is sufficient to keep the lung alive. Also, the ventilation of the lung continues undisturbed, though there is hardly any gas exchange because the functional (pulmonary) circulation in the affected lung has been excluded.

The structures of the normal lung, visible on a roentgenogram, are for the most part conditioned by the vessels filled with blood, and more pronounced changes in the blood content of the lung can be estimated on a plain roentgenogram. Oligemia is observed, *e.g.*, in pulmonic stenosis, and in many instances of advanced emphysema, pulmonary hypertension, and pulmonary embolism. Pleonemia is seen in left-to-right shunts, and in the contralateral lung in agenesis of the right or left pulmonary artery. It should be expected to occur, also, in massive unilateral embolism. Ardran, and DeCoster *et al.* observed by angiocardiography an increased vascular bed in the unobstructed lung, while Nordenström, applying electrokymography for densographic studies in unilateral occlusion of the pulmonary artery in dogs, found

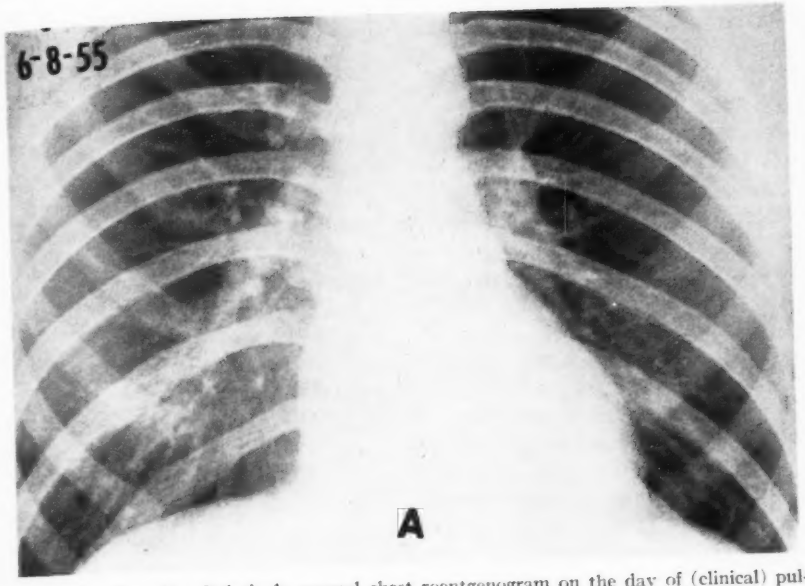

Fig. 2A. Case II. Relatively normal chest roentgenogram on the day of (clinical) pulmonary embolism.

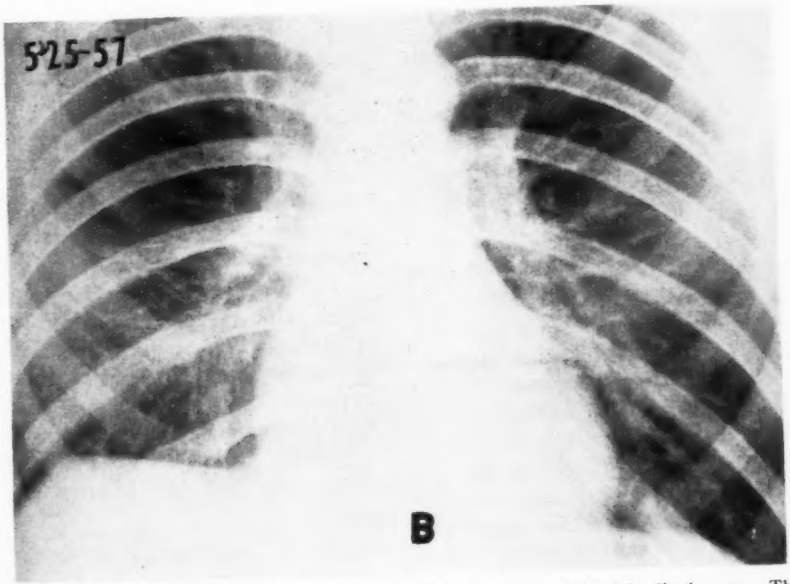

Fig. 2B. Case II. Two years after Fig. 2A. Slight elevation of the right diaphragm. The right lung field shows increased radiance. Instead of the normal hilar vessels and their major branches, small irregular vessels are seen, probably mainly the ramifications of the bronchial circulation. On the left, the hilar and major peripheral vessels are wider than before, especially in the lower lung field.

oligemia in the ipsilateral and pleonemia in the contralateral lung in many of his experiments (11–13).

The roentgenologic observations presented agree with clinical expectation and experience, and with pathological and experimental observations. In acute, massive unilateral embolism the blood is shunted to the unoccluded side as long as the obstruction of the embolized side lasts. The radiance of this lung field is increased as compared with the other side. This is due to the oligemic capillary background. Furthermore, the visible individual vessels are narrower and fewer in number. The hilar shadows may be plump if the embolic obstruction is not located immediately beyond the bifurcation of the pulmonary artery. This plumpness of the hilar shadows is caused by the widened hilar arteries, distended either by the embolothrombus lodged there or by pulmonary hypertension associated with pulmonary embolism. In the unobstructed lung the hilar and peripheral vessels are wider, owing to the overflow of blood to this side. This difference between right and left may be well recognized on a technically good roentgenogram.

When the large embolus breaks up, dissolves, or recanalizes, or when the reflex vasospasm subsides, the normal blood flow through the embolized lung may be restored and the overflow to the other side stopped. If one examines such a patient at frequent short intervals, one may observe slow restoration of the vascular tree to normal on the embolized side. At the same time, the vessels of the other side return to their normal caliber, though this is much less conspicuous. If, however, the embolism leads to chronic narrowing of the arterial bed on the affected side, the overflow to the unoccluded side and the widening of the vessels there become permanent.

Concerning the differential diagnosis, in addition to agenesis and hypoplasia of a pulmonary artery, one should consider unilateral obstructive emphysema with or without gross bronchial obstruction. However, nothing besides the increased radiance points to emphysema; the chest is symmetrical, but not deformed, the position of the diaphragm is normal, and there is no respiratory mediastinal shift. Bronchoscopy and bronchography would be normal. Other conditions to be differentiated are unilateral restrictive emphysema, *e.g.*, after pleurisy; mediastinal or hilar primary or metastatic carcinomatous masses constricting or invading the pulmonary artery; finally, the recently described condition of idiopathic unilateral hyperlucent lung (14), still incompletely understood.

CONCLUSION AND SUMMARY

In massive unilateral pulmonary embolism the entire or greater portion of the pulmonary arterial blood is shunted to the unoccluded lung.

This condition may be recognized on a plain roentgenogram. The lung field of the embolized side is more translucent presenting the picture of the oligemic lung, while the nonobstructed side shows dilated hilar and peripheral vessels, the appearance of pleonemia. These changes may be transient during the acute stage of embolism, or permanent in the case of permanent massive embolothrombotic obstruction.

It is not yet clear whether angiocardiography can be performed with impunity in instances of suspected embolism. On the other hand, it seems that electrokymography may provide a sensitive tool for the discovery of diminution or absence of pulsation and flow in smaller pulmonary areas (Marchal, 15; Lissner, 16).

NOTE: The author expresses his gratitude to Drs. Egon G. Wissing and Albert P. Cox of the Veterans Administration Hospital, Boston, for providing the greater part of the data for the two cases reported here.

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SUMMARIO IN INTERLINGUA

Embolismo Pulmonar Unilateral con Augmento del Circulation Compensatori per le Non-Occludite Pulmon

In massive embolismo pulmonar unilateral, le totalitate o un grande portion del sanguine pulmono-arterial es transferite al pulmon non occludite. Iste condition es recognoscibile in un roentgenogramma conventional. Le campo pulmonar al latere embolisate es plus translucente, monstrante le aspecto del pulmon oligemic, durante que le non-obstruite latere exhibi dilatate vasos hilar e peripheric, i.e., le aspecto de pleonemia. Iste alterationes pote esser transiente, durante le stadio acute de embolismo, o permanente, in le caso de chronic obstruction massive.

Tracheobronchial Papillomatosis Treated by Roentgen Irradiation

Report of Two Cases[1]

JAMES BLACKMAN, M.D., SIMEON T. CANTRIL, M.D.,[2] PAUL K. LUND, M.D., and DONAL SPARKMAN, M.D.

THE TWO CASES to be presented here contain much of clinical and pathologic interest. Papillomatosis of the larynx has been treated many times in the past, and with doses bordering on the cancerocidal. The results, however, have not been effective with any constancy. When these two cases came to our attention, we searched the literature for any leads on radiation therapy other than in laryngeal papillomata but were unsuccessful in finding reference to such treatment. The reasons for our embarking upon this project will be found in the protocol.

It was of considerable interest to us that *The New England Journal of Medicine* reported, in September 1957 (1), a case with autopsy, in which the pulmonary findings were very similar to those in our Case II. This latter publication prompted us to believe that the condition is sufficiently rare, and the usual treatment so disappointing, that an attempt to use some other method than surgical relief of obstruction might be worthwhile.

From the standpoint of radiation therapy, the dose delivered to the trachea and main stem bronchi borders on that which we utilize in bronchogenic cancer. Whether a lesser dose would have been effective in causing regression of the papillomata is not known, but from our experience in the larynx we would believe not. Roentgen therapy is also a medium not applicable to the treatment of papillomata in the smaller bronchi and infiltrating the parenchyma of the lung. Hence it is limited to the larynx, trachea, and bronchi within the mediastinum. In Case I our field during the second series of irradiation did impinge upon the medial aspect of the parenchyma bilaterally but not sufficiently to produce fibrosis of any consequence.

The cases are also of interest in that, although the condition is benign pathologically, the ultimate outcome is precarious in view of the chronicity of obstruction and attendant complications.

CASE I: A 40-year-old white male, a pipefitter, was first admitted to the Swedish Hospital in February 1954. His history was one of increasing dyspnea associated with cough and intolerance to the fumes and dust of his work. He dated the onset of his symptoms to 1951. Bronchoscopic examination in February 1954 revealed a red, granular mass on the posterior tracheal wall and a similar-appearing nodule at the orifice of the right upper and lower lobe bronchi, with marked tracheal and bronchial obstruction. Vocal cords were noted to be fibrotic in their anterior half. Tissue was removed from the trachea and bronchi to improve the airway and was reported pathologically as squamous papilloma. The patient was re-admitted in April 1954, when bronchoscopy was again done and further papillomata were removed (Fig. 1).

The patient was first seen in the Tumor Institute in July 1956 with dyspnea of such severity that he could not walk 100 yards without becoming breathless and could not speak without frequently stopping for air. His vital capacity in June 1956 was 2.4 liters in 4 seconds (55 per cent of normal). At this time he gave no outward evidence of poor health other than the extreme dyspnea. On auscultation of the thorax, there was marked wheezing both on inspiration and expiration, more marked on the left side.

Bronchograms made in February 1955 by Dr. James Blackman (Fig. 2) demonstrated multiple irregular polypoid masses measuring up to 1 cm. throughout the trachea and right and left main-stem bronchi. In the tertiary bronchi were several

[1] From the Tumor Institute and Laboratories of the Swedish Hospital, Seattle, Wash. Accepted for publication in December 1958.

Radiation therapy with 2,000 kv performed with a Van de Graaff generator made available to the Tumor Institute of the Swedish Hospital by the U. S. Public Health Service for purposes of clinical research.

Patient in Case II studied and hospitalized with funds supplied by Damon Runyon Cancer Research Grant.

[2] We regret to report the death of Dr. Cantril on Sept 10, 1959.

rounded masses which were thought to represent papillomata. The roentgenogram of the chest itself showed some increase in emphysema.

Bronchoscopy found the vocal cords grossly normal. Beginning about 2 cm. below these were large papillomata producing occlusion. The degree of obstruction and the bleeding coincident with attempts to pass the bronchoscope prevented the visualization of the lower trachea and main-stem bronchi. Tissue removed was again reported as squamous-cell papilloma.

The otolaryngologist who originally examined this patient in February 1954 had consulted the Tumor Institute to ascertain whether radiation therapy could offer any relief of obstruction. At this time roentgen therapy was not advised, largely due to a misconception that such well differentiated papillomata would not respond to irradiation. It was believed also that the condition was in all probability widespread throughout the lesser bronchi and that pulmonary fibrosis might be more incapacitating than the disease itself. In retrospect, this denial of radiation therapy in 1954 appears ill-advised. In July 1956, radiation therapy was offered purely as a therapeutic trial. The patient's condition was such that the only other recourse was repeated and incomplete removal of papillomata.

On July 9, 1956, roentgen therapy, at 2,000 kv, was begun through an anterior mediastinal field of 7 × 15 cm. The superior limit was placed at the immediate subglottic level. With a mid-thoracic dose of 55 per cent, 2,390 r were delivered through the anterior field in an elapsed time of twenty-six days. Thereafter irradiation was continued through an opposing posterior field over a total period of fifty-one days, to deliver a total mid-thoracic dose of 5,000 r. Respiration improved markedly during treatment and at the completion of therapy had returned to an apparently normal status.

Six weeks following completion of irradiation, bronchoscopy and bronchography were repeated. The larynx was found to be free of papillomata. The lumen and mucosa of the trachea were everywhere normal. The carina was thin and sharp, moving normally with respiration. Just distal to the apical division of the right inferior bronchus, three small papillomata of less than 2 mm. projected into the lumen, reducing its caliber by approximately 30 per cent. At the beginning of the lower lobe bronchus on the left and just distal to the orifice of the superior lobe, were two small papillomata producing no occlusion. Bronchograms at this time showed the trachea and main-stem bronchi to be clear, with moderate cylindrical bronchiectasis of the right lower lobe (Fig. 3).

Vital capacity six weeks after irradiation was 4.6 liters in 3.8 seconds as compared with the previous 2.4 liters in 4 seconds.

The patient was followed periodically and in January 1957 was entirely asymptomatic and was working as a pipefitter. On examination of the larynx, two papillomata, each approximately 2 mm. diameter, were noted, located symmetrically at the junction of the true and false cords on opposite sides. No papillomata had been previously seen on examination of the larynx. The subglottic area and upper trachea were well visualized and no papillomata were discovered. It is recalled that the larynx was not within the field of irradiation. These papillomata were again noted in the larynx three months later but seven months after that they had spontaneously disappeared.

Fig. 1. Case I. Low-power photomicrograph of papilloma from trachea, April 1954. Tissue removed from right inferior bronchus in August 1957 was of identical histologic appearance.

Ten months following irradiation the patient experienced increasing dyspnea. His inspiratory wheeze could be heard across the examining room. Bronchoscopy demonstrated the trachea in the midline, its caliber normal and without evidence of papillomata throughout its length. The right main-stem bronchus and the orifices of the right superior and intermediary bronchi were normal. At the beginning of the right inferior bronchus was a large mass of papillomata occluding the entire inferior bronchial orifice and with no apparent air exchange. A sufficient amount of this obstructive mass was removed to open the inferior bronchus. On the left, at the origin of the inferior lobe bronchus, was an almost complete occlusion of the bronchial lumen by three papillomata. The orifice of the left superior lobe bronchus was visualized and was patent. Pathologic examination of tissue removed again disclosed squamous-cell papilloma.

The problem as presented ten months following

Fig. 2. Case I. Bronchograms of February 1955. In all views but particularly in the lateral and oblique one can visualize the multiple rounded masses on the tracheal and bronchial walls representing papillomata. Saculation is noted in the more distal bronchi.

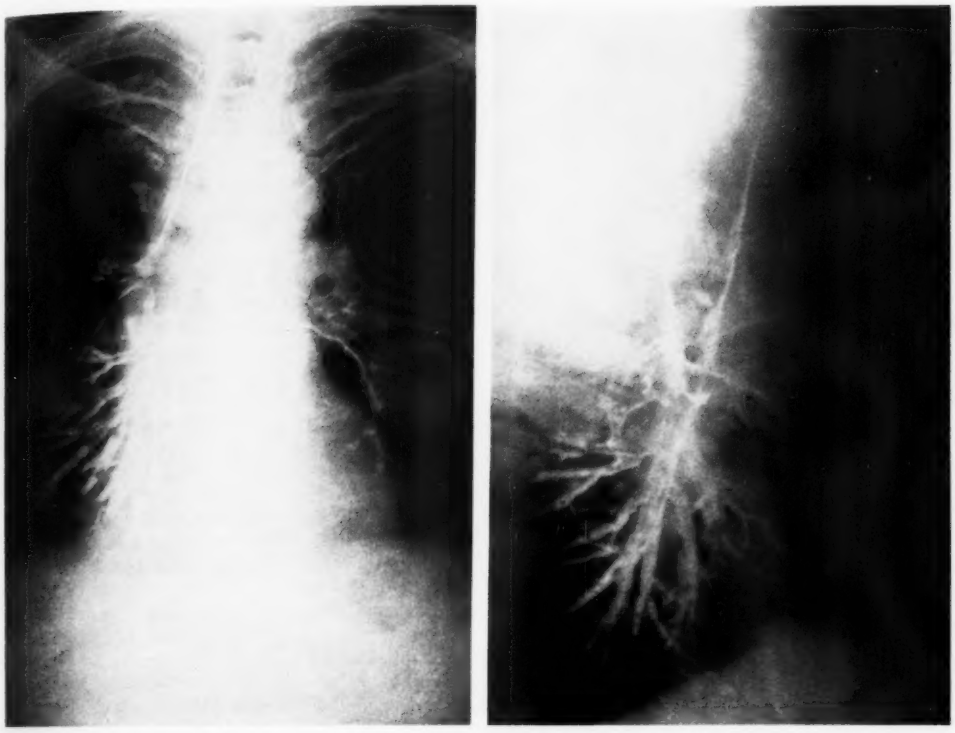

Fig. 3. Case I. Bronchogram Oct. 12, 1956, made six weeks after completion of the first series of irradiation. The papillomata in the trachea and bronchi are not at this time visible. There was moderate saccular and cylindrical dilatation of the bronchi of the superior segment of the right lower lobe.

the initial irradiation of the trachea and main-stem bronchi was that of further obstruction to inferior lobe bronchi which had not been included within the irradiated volume. It was thought advisable to reinstitute irradiation to include the obstructed orifices of the lower lobe bronchi. Accordingly, treatment was directed transversely through anterior and posterior fields, 6 × 12 cm., which did not impinge upon the initial superior fields. In a period of forty-four days, a mid-thoracic dose of 5,000 r was administered. Again there was marked improvement in respiratory function and the patient was asymptomatic by the time the treatment was concluded.

Five weeks following completion of the second course of irradiation, bronchoscopy and bronchography were again repeated. No papillomata were seen in the larynx, nor was there any obstruction in the trachea. On the posterior tracheal wall, however, beginning approximately 3 inches above the carina, were multiple white flecks, a few millimeters in diameter, having the appearance of calcification.

Fig. 4. Case I. Roentgenogram, May 1958, eight months after completion of second course of irradiation. Patient asymptomatic.

Fig. 5. Case II. Photomicrograph of papilloma removed from the trachea, showing the characteristic mature squamous-cell elements with hyperkeratosis. All other papillomata removed from the trachea and bronchus showed a similar histologic picture (×4.5).

Examination of left and right main-stem bronchi and the bronchi leading to both the left and right lower lobes showed these to be everywhere open, of normal caliber, and free of papillomata. The bronchogram showed excellent filling bilaterally and no sacculation was seen. The parenchyma of the lung appeared quite within normal limits. At this time the patient was back at work and completely asymptomatic.

Bronchoscopy nine months following completion of the second series of irradiation and approximately two years from the date of his first treatment gave no indication of papillomata within the trachea and bronchi. A roentgenogram of the chest at this date is reproduced in Figure 4.

It is anticipated that this patient may in the future have further atelectasis from papillomata. Case II demonstrates the degree to which these may affect the lung parenchyma by formation of tumor nodules.

CASE II: A 59-year-old female gave a history of dyspnea, hoarseness, and cough for eight years. During the previous seven years,she had had numerous bronchoscopies and laryngoscopies for removal of papillomata of the larynx, trachea, and bronchi. In 1951, resection of the left lower lobe and lingula had been done at St. Luke's Hospital, Cleveland, because of persistent bronchiectasis associated with fever. Microscopic sections of papillomata removed in the period 1950–1955 were sent to us by Dr. A. J. Segal of Cleveland and were identical with others received from the USAF Hospital, Anchorage, Alaska, where they were obtained in 1957. The patient was referred to the Tumor Institute of the Swedish Hospital in July 1957 by the USAF Hospital in Anchorage. She had first been seen there in May 1956, almost prostrate with hypoxia. Following oxygen therapy bronchoscopy was possible and numerous papillomata were removed from the larynx, trachea, and left main-stem bronchus. In the interval between May 1956 until her referral in July 1957, six separate procedures of laryngoscopy and/or bronchoscopy with removal of papillomata were required to maintain an airway adequate for respiration.

When the patient arrived July 6, 1957, she was markedly dyspneic, orthopneic, and unable to leave her bed. There was marked stridor with hoarseness. Vital capacity was 1 liter in 5 seconds. The right lung was hyperresonant. Examination of the larynx indicated good mobility of both vocal cords with scarring from previous removal of papillomata.

On bronchoscopy, the lumen of the trachea was seen to be reduced, at a distance of 3 inches below the vocal cords, to approximately 30 per cent of normal by two separate papillomatous masses. It was not deemed wise to force the bronchoscope through the trachea, which procedure would be fraught with bleeding. A portion of one of the papillomata was removed and it was found to be comparable histologically to those previously examined (Fig. 5). Bronchography was not done at this time because of the patient's precarious pulmonary status.

Roentgenograms of the chest revealed complete atelectasis of the remaining left lung, with shift of mediastinal structures and compensatory emphysema of the right lung. Several radiolucent areas were noted in the upper portion of the left hemithorax, thought to represent abscesses in bronchiectatic cavities. A tomogram of the chest visualized the irregularity of the trachea due to papillomata (Fig. 6).

Experience with radiation therapy in Case I led us to believe that we might improve the tracheobronchial airway prior to performing bronchography to learn the degree and extent of obstruction. Radiography with 2,000-kv x-rays for purposes of localizing the fields of treatment gave a good demonstration of the obstructed trachea and left main-stem bronchus. Roentgen therapy was begun four days following admission. During the subsequent fourteen days, the patient was treated daily through an anterior mediastinal field of 9 × 19 cm. with 2,000-kv roentgen therapy, daily incident doses increasing from 100 to 200 r daily. The depth dose within the mid-thorax was 62 per cent. In the first two weeks, 2,400 r had been delivered to the trachea, carina, and remaining left stem bronchus. By then the patient's respiratory status had considerably improved and a bronchogram was obtained (Fig. 7). The obstructing tumor in the trachea was smaller than it had appeared on laminagrams taken twelve days before. The bronchi of the right lung were well

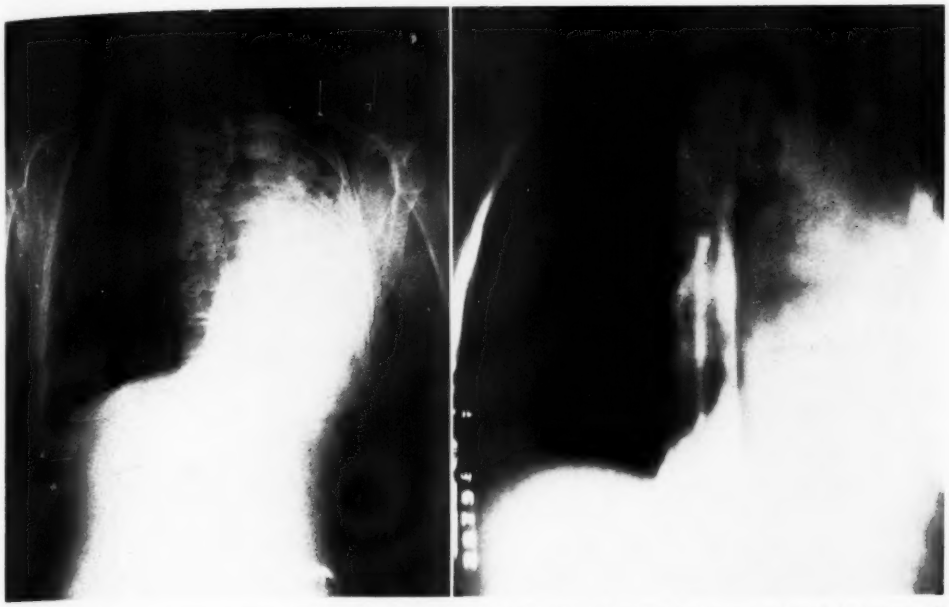

Fig. 6. Case II. Roentgenogram and tomogram of chest, July 1957. The marked irregularity of the inner wall of the trachea secondary to papillomata is well demonstrated on the tomogram. There is complete obstruction of the left main bronchus.

visualized and no obstructing tumor was seen. A small amount of medium entered the left upper lobe and left lower pleural space, indicating a bronchopleural fistula.

Roentgen therapy was continued over a total elapsed time of thirty-eight days, later through an opposing posterior mediastinal field. The delivered dose within the mid-mediastinum was 5,170 r. The patient's general condition continued to improve so that she could be out of bed and walk about the wards. Two factors in her disease were relatively unchanged. One was the production of a thick, greenish sputum which had been noted on admission. The second was pain over the left lower chest wall. The roentgen therapy had in no way improved the status of the empyema in the left lower thoracic cavity other than permitting drainage through raising of purulent sputum. It was our opinion that the empyema would not resolve spontaneously.

One month following completion of irradiation resection of the left superior lobe and excision of the encapsulated empyema were accomplished. The pleural space was found to be completely obliterated, and a shrunken and airless superior lobe was densely adherent to the thoracic wall and mediastinum. Although the operative procedure was long, the patient withstood it satisfactorily.

The postoperative course was extremely stormy, beginning approximately twelve hours after surgery,

Fig. 7. Case II. Bronchogram obtained during the third week of therapy. Projecting papillomata of the tracheal wall are present. The right bronchial tree appears unobstructed. There is obstruction of the left main bronchus, with a small amount of contrast material entering the left lower pleural space by way of a bronchopleural fistula.

Fig. 8. Case II. Roentgenogram of mediastinum taken three weeks following lobectomy, with 2,000 kv, showing regularity of the tracheal contour. The carina is visualized, with closure of the left main-stem bronchus.

when the patient went into profound shock and the temperature rose to 107.8°. In addition to blood and intravenous Levophed to maintain blood pressure, she was given hydrocortisone intravenously. Her improvement under this regime led the attending physician to discover that she had been on Meticorten for approximately six weeks as part of a regime to permit withdrawal of barbiturates and codeine. With adequate doses of cortisone, her condition improved rapidly, and within ten days she was up and about.

Three weeks postoperatively bronchoscopy and bronchography were repeated. It was only when the bronchoscope reached the level of the lower trachea just above the carina, that two small papillomata, measuring approximately 3 mm., were noted on the left and right lateral walls. There was no obstruction and no other papillomata were seen in the trachea or right bronchial tree. The bronchogram indicated no sacculation of the medium. Good visualization was obtained of the bronchi of the right lung, along with trachea and stump of the remaining left bronchus. A roentgenogram taken with 2,000-kv x-rays demonstrated a relatively free tracheal airway as compared with the original films (Fig. 8). A roentgenogram of the chest indicated a shift of the trachea from its former left lateral position to a more central position, though it still did not reach the midline (Fig. 9).

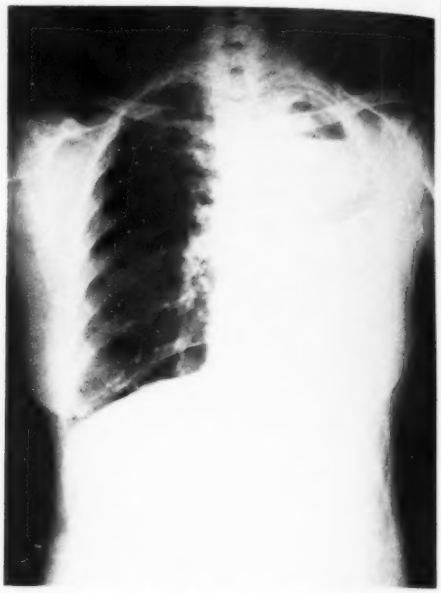

Fig. 9. Case II. Roentgenogram of the chest taken fourteen days following lobectomy. This indicates a shift of the trachea back toward the midline, but without reaching a normal position.

The resected lobe presented infiltration secondary to atelectasis, but we were surprised to see on the cut surfaces of the lobe solid conglomerate tumor nodules (Fig. 10). The microscopic appearance of the lung is seen in Figure 11.

The patient returned to Alaska some three weeks postoperatively. A bronchopleural fistula and left empyema developed approximately two months after left lobectomy. The empyema was drained, and the patient was later evacuated to the Air Force Hospital at Parks Air Force Base, Calif. On admission there she was in very poor condition but on gradual improvement further drainage of the empyema was done by rib resection. She died in shock within twenty-four hours.

Postmortem examination was done by Major Robert E. Pierce. No papillomata were found in the trachea or bronchus. The empyema cavity was noted in the left upper thorax which had previously been drained. The right lung weighed 800 gm., with marked edema in the middle and lower lobes and consolidation of the upper lobe. Microscopically the tissues from the right lung showed generalized hyperemia. No papillomata were noted. A lymph node taken from the hilus of the lung exhibited marked pigmentation, with numerous secondary follicular centers.

Fig. 10. Case II. Gross photograph of a hemisection of the upper lobe of the left lung removed surgically. Remarkable is the pronounced cylindrical and saccular bronchiectasis, with many bronchi containing yellowish-white friable papillary tumors. In many areas the tumor nodules show gross coalescence, with several areas exhibiting gross infiltration of the pleura.

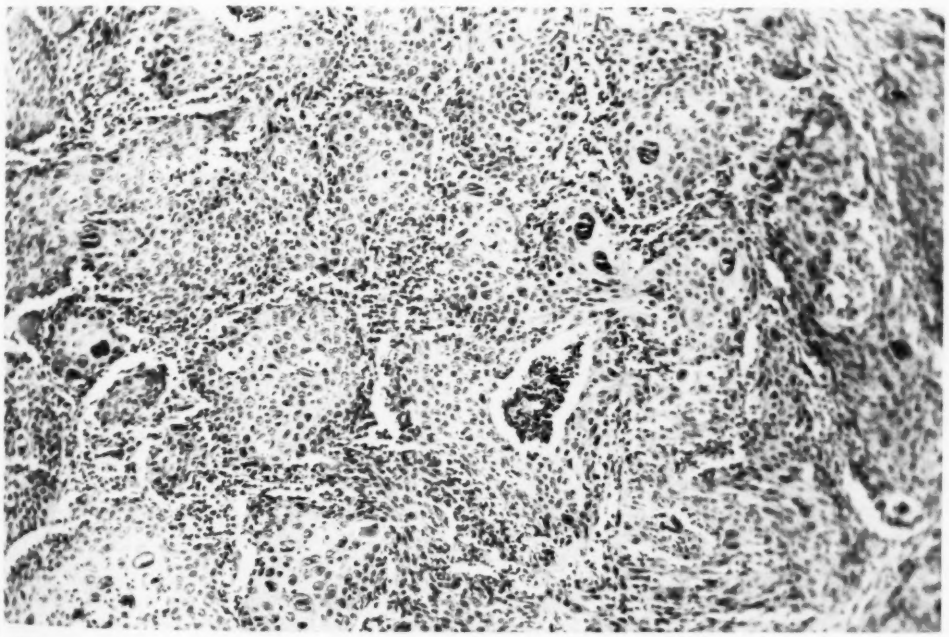

Fig. 11. Case II. Photomicrograph of a histologic section taken from the left upper lobe as viewed in Figure 10. These coalescing islands of squamous elements show considerable pleomorphism of the cell structures, including an occasional mitotic figure. These gross and microscopic pictures suggest malignancy, but the long history and absence of metastatic lesions at autopsy reaffirm the view that the biological behavior of these lesions is that of local and multifocal infiltration rather than true malignancy with ability to metastasize (×80).

SUMMARY

Two cases of tracheobronchial papillomatosis are reported, in each of which papillomatous masses obstructing the air passages responded favorably to 2,000-kv roentgen therapy.

REFERENCE

1. Case Records of the Massachusetts General Hospital; Case 43361. New England J. Med. 257: 465, Sept. 5, 1957.

Tumor Institute
Swedish Hospital
Seattle 4, Wash.

SUMMARIO IN INTERLINGUA

Papillomatosis Tracheobronchial Tractate per Roentgeno-Irradiation: Reporto de Duo Casos

Es reportate duo casos de papillomatosis tracheobronchial. In ambes, le massas papillomatose que obstrueva le vias aeree respondeva favorabilemente a roentgenotherapia con 2.000 kv. Le prime patiente recipeva duo cursos de roentgeno-irradiation. Duo annos post le prime curso, ille exhibiva nulle indicio bronchoscopic de papillomas intra le trachea o le bronchos, sed il esseva previdite que atelectasis poterea disveloppar se subsequentemente como resultato de papillomas. Le secunde patiente moriva in choc post resection costal pro drainage de empyema. Le necropsia revelava nulle papillomas in le trachea o le bronchos.

In iste casos, le dose de radiation delivrate al trachea e le broncho del trunco major esseva simile a illo usate per le autores in le tractamento de carcinoma bronchogene. Si o non un minus forte dose haberea essite equalmente efficace non es cognoscite, sed super le base del experientia general in le tractamento del larynge, un tal supposition pare dubitose. Le tractamento non es applicabile a papillomas del bronchos plus micre o a papillomas que infiltra se in le parenchyma pulmonar.

Iste casos es etiam de interesse proque le ultime consequentia del condition, in despecto del facto que illo es pathologicamente benigne, remane precari a causa del chronicitate del obstruction e del complicationes associate.

Dose Distribution with Four Radiation Technics for Carcinoma of the Breast[1]

MARY LOUISE MEURK, B.A., and FLORENCE C. H. CHU, M.D.

SINCE IONIZING radiation has been effectively employed in the management of carcinoma of the breast, many technics have been developed for postoperative and inoperable cases. In as much as the response to radiation of both cancer and normal tissue depends on the dose, the basic information which is fundamentally necessary regarding any technic is the exact dosage to the primary tumor, the regional lymphatic drainage areas, and the normal lung tissue. The study to be described here was done to determine the dose delivered at these significant anatomic sites by the different radiation technics which are currently used or have been used in the treatment of inoperable and postoperative carcinoma of the breast.

TECHNICS STUDIED

The technics studied either had been or are being used at the Memorial Center (New York). They represent two types of direct-portal technics and one type of tangential technic using x-radiation of two different energies.

The details of the tangential technic with 250 kevp and 1,000 kevp x-rays have been reported by Chu *et al.* (1). A brief description, however, will be provided here.

By using three fields, medial tangential, lateral tangential, and supraclavicular, the breast, chest wall, and internal mammary, axillary, and supraclavicular areas are irradiated *en bloc*. The medial and lateral fields, averaging 26 × 12 cm. each, are tangential to the surface of the chest wall. Together they irradiate the breast, the chest wall, and the axillary, internal mammary, infraclavicular, and part of the supraclavicular lymphatic areas. The edge of the medial tangential field lies on a line 2 cm. beyond the midline of the sternum on the contralateral side. The skin margin of the lateral tangential field lies along the posterior axillary line.

The supraclavicular field, averaging 14 × 17 cm., is so directed that its central axis is approximately parallel to the sagittal plane of the body. It irradiates the supraclavicular and axillary lymphatic areas and contributes to the dose delivered to the infraclavicular area, the chest wall, the breast, and the internal mammary node-bearing areas. The medial border of this field passes through the sternal notch. The lateral edge of the field coincides with the anterior axillary line with the arm abducted. The anterior margin is 2 cm. anterior to the most prominent part of the breast or chest wall. The posterior margin follows the anterior border of the trapezius muscle.

Bolus is used with all fields in the tangential technic.

Technic I: 250-kevp Tangential: The 250-kevp tangential method was used at Memorial Center for postoperative treatment from 1949 to 1953 and is still employed for palliation of some inoperable breast carcinomas and recurrent chest wall lesions. The treatment is planned to deliver a tissue dose, calculated at the intersection of the three beam axes, of 3,500 to 4,000 r in three and one-half weeks.

The factors used on the phantom in this study were:

A. 250 kevp. 2.0 mm. Cu h.v.l.
B. Size of fields and target skin distance
   (1) Medial tangential: 26 × 12 cm. at 55 cm.
   (2) Lateral tangential: 26 × 12 cm. at 55 cm.
   (3) Supraclavicular: 16 × 14.5 cm. at 50 cm.

[1] From the Department of Physics (M.L.M.) and the Department of Radiation Therapy (F.C.H.C.), Memorial Center for Cancer and Allied Diseases, New York, N. Y. Presented in part at the Eighth International Congress of Radiology, Mexico City, July 1956.
Accepted for publication in November 1958.

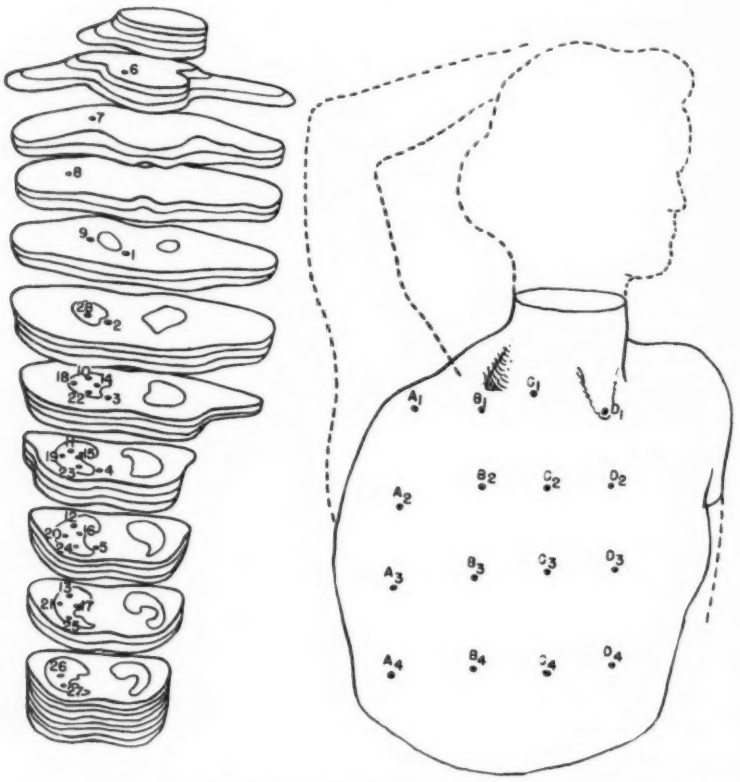

Fig. 1. Diagram showing the location of all points at which dose measurements were made. Points 1 through 28 indicate points within the phantom. Points A-1 through D-4 indicate points on the surface of the patient or phantom.

C. Dosages
   (*a*) Intended tissue dose (calculated at the intersection of three beam axes): 4,000 r
   (*b*) Surface dose (calculated on the bolus at center of the field):
   Tangential fields: 3,900 r
   Supraclavicular field: 2,800 r

Technic II: 1,000-kevp Tangential: This method has been used for irradiating inoperable mammary carcinoma since 1949. The tissue dose ranges from 4,000 r in four weeks to 6,000 r in seven weeks.

The factors used on the phantom in this study were:

A. 1,000 kevp. 3.4 mm. Pb h.v.l.
B. Size of fields and target skin distance
   (1) Medial tangential: 26 × 12 cm. at 100 cm.
   (2) Lateral tangential: 26 × 12 cm. at 100 cm.
   (3) Supraclavicular: 18.5 × 16 cm. at 70 cm.
C. Dosages
   (*a*) Intended tissue dose (calculated at the intersection of the three beam axes): 5,000 r
   (*b*) Surface dose (calculated on the bolus at center of the field):
   Tangential fields: 3,400 r
   Supraclavicular field: 3,000 r

Technic III: Three-Field Direct-Portal: This technic has been used at the Memorial Center routinely for postoperative irradiation since 1953. In this procedure the chest wall is not irradiated. A single anterior internal mammary field and two opposing supraclavicular fields are irradiated with 250-kevp x-rays, with bolus for the supraclavicular fields only. The treatment plan is to deliver a tissue dose of 3,500 r calculated at the midplane of the opposing supraclavicular fields and 3,500 r calculated at 4 cm. depth in the internal mammary field in three and one-half weeks.

The factors used on the phantom in this study were:

A. 250 kevp. 2.0 mm. Cu h.v.l.
B. Size of fields and target skin distance
  (1) Internal mammary: 15 × 8 cm. at 70 cm.
  (2) Supraclavicular anterior: 13 × 15 cm. at 70 cm.
  (3) Supraclavicular posterior: 13 × 15 cm. at 70 cm.
C. Dosages
  (*a*) Intended tissue dose:
    Internal mammary (calculated at the depth of 4 cm.): 3,500 r
    Supraclavicular (calculated at the midplane, 7.5 cm.): 3,500 r
  (*b*) Surface dose:
    Internal mammary field (calculated at the center of the field): 4,600 r
    Supraclavicular fields (calculated at the center of each field): 3,000 r

Technic IV: Five-Field Direct-Portal: A five-field direct-portal method was used in Memorial Hospital prior to 1949. The supraclavicular area and axilla were irradiated through three portals with 250 kevp: two opposing supraclavicular portals and an axillary port directed toward the apex of the axilla and supraclavicular region. The chest wall was irradiated by two low-voltage fields. No bolus was used with any of these ports. Only air dose was used at that time. The over-all time was about two and one-half weeks.

The factors used on the phantom in this study were:

Fields	*Kevp*	*h.v.l.*	*Size*	*TSD*	*Air Dose*
Supraclavicular, anterior	250	2.0 mm. Cu	13 cm. × 15 cm.	50 cm.	2,000 r
Supraclavicular, posterior	250	2.0 mm. Cu	13 cm. × 15 cm.	50 cm.	2,000 r
Axillary, direct	250	2.0 mm. Cu	10 cm. × 10 cm.	50 cm.	1,750 r
Medial chest wall	120	3.4 mm. Al	14 cm. × 10 cm.	30 cm.	1,500 r
Lateral chest wall	120	3.4 mm. Al	18 cm. × 10 cm.	30 cm.	1,500 r

METHOD OF MEASUREMENT

A. *Equipment Necessary for Dosimetry Study*

(*a*) *Phantom:* A phantom woman was constructed from layers of unit density Presdwood into which ionization chambers could be inserted at predetermined spots so that an accurate measurement of the delivered dose at these sites would be possible. Each layer was designed on the basis of a standard anatomical cross-section (2). Cork of the density of 0.3 gm./cm.^{3} replaced the Presdwood in lung-containing volumes. The portion of the phantom used in this study extended from the fourth cervical vetebra to the lower margin of the twelfth thoracic vertebra. The shoulder of the treatment side was adjusted to simulate the treatment position, *i.e.*, with arm abducted. The phantom was constructed without breasts, as in the postoperative situation. For the tangential technics, where bolus is used, the presence or absence of the breast on the phantom would not significantly affect the dose to the lung or node-bearing areas. The anteroposterior and lateral diameters of the phantom were 19.5 and 33 cm., respectively.

Dose measurements in the phantom were made at the points shown in Figure 1. These points were chosen as representative of the regional lymphatic drainage areas and pulmonary tissue. Points 1 through 5 represent the internal mammary nodes at different levels. Point 6 is at the midneck. Point 7 represents the supraclavicular lymphatic areas while points 8 and 9 represent the apex of the axilla. For the lung measurements points 10 through 13 are in the posterior region, while points 14 through 17 are in the medial lung tissue near the hilus. Points 18 through 21 are in the lateral lung and 22 through 25 in the anterior portion of the lung; 26 and 27 are at the base, and 28 is at the apex of the lung tissue.

For surface dose measurements, 16 evenly spaced intervals on the chest wall were chosen, represented by points A-1 through D-4 (Fig. 1).

(*b*) *Measuring Instruments:* Doses were measured with a Baldwin-Farmer electrometer using the BD2 intracavitary condenser ionization chambers (3). These chambers were selected because of their

Fig. 2. Ionization chambers shown in place before bolus was added for medial tangential field; Bakelite applicator at 55 cm. TSD, 250 kevp, and 2.0 mm. Cu h.v.l.

Figure 3 ⟶

TABLE I: RANGE AND AVERAGE TOTAL DOSE DELIVERED WITHIN THE PHANTOM FOR EACH TREATMENT TECHNIC

Planned Tissue Dose	Technic I 250-kevp Tangential 4,000 r		Technic II 1,000-kevp Tangential 5,000 r		Technic III Three-Field Direct 3,500 r		Technic IV Five-Field Direct Dose Prescribed in Terms of Air	
	Range	Average	Range	Average	Range	Average	Range	Average
	r	r	r	r	r	r	r	r
Internal mammary lymph nodes	1,900 2,800	2,300	3,600 4,100	3,800	3,300 7,000	4,100	1,500 4,000	2,500
Apex of axilla	3,000 3,400	3,200	3,300 4,500	4,400	3,600 4,500	4,100	3,500 4,000	3,800
Supraclavicular lymph nodes	...	2,900	...	3,300	...	4,600	...	4,000
Posterior lung	1,300 1,800	1,600	1,600 2,400	2,000	1,600 3,200	2,100	1,100 2,700	2,900
Medial lung near the hilus	1,300 2,200	1,700	1,700 2,700	2,200	1,300 3,000	2,400	1,100 2,700	1,800
Lateral lung	2,300 2,600	2,500	2,200 3,700	3,200	Less than 600 1,400		1,500 3,300	2,300
Anterior lung	2,800 3,100	3,000	3,300 4,900	4,300	Less than 600 3,900		1,700 2,700	2,000
Apex of lung	...	2,500	...	4,200	...	3,900	...	4,000
Base of lung	1,500 2,200	1,900	1,600 1,900	1,800	...	...	1,500 1,700	1,600

small measuring volume (6.3 cu. mm.) and their rather large measuring range (from 20 to 800 r).

Calibration factors were found by comparing the Baldwin-Farmer chambers to a Victoreen chamber calibrated by the Bureau of Standards. Each chamber was calibrated at each kilovoltage and half value layer employed in the clinical situations. Calibration factors were determined both on the surface and within an infinite Presdwood phantom. The chambers showed a quality dependence that averaged a 10 per cent change in calibration factor from 1,000 to 120 kevp. All factors used were determined from the average of six measurements. Forty-two of the factors so determined had an average deviation of 3 per cent or less, and four of the factors ranged from 4 to 6 per cent.

The position of the chamber within the scattering medium with respect to the beam affected the sensitivity of the chamber. The reading was reduced by 5 per cent when the radiation was incident through a solid angle of less than 60° along the axis and from the back of the chamber. Care was taken in using these chambers to avoid this source of error.

B. Dose Measurement

For the measurement of the points inside the phantom, the ionization chambers were inserted into the preselected anatomic sites. The dose contributed by each treatment field was determined for each technic. An average of six measurements was used to determine the dose at each point.

For the surface dose measurements, the

Fig. 3. Dose in hundreds of roentgens measured within the phantom.
Technic I: Three-field tangential; 250 kevp, 2.0 mm. Cu h.v.l., planned tissue dose 4,000 r.
Technic II: Three-field tangential; 1,000 kevp, 3.4 mm. Pb h.v.l., planned tissue dose 5,000 r.
Technic III: Three-field direct; 250 kevp, 2.0 mm. Cu h.v.l., planned tissue dose 3,500 r.
Technic IV: Five-field direct; 250 kevp, 2.0 mm. Cu h.v.l. and 120 kevp, 3.4 mm. Al h.v.l. Air dose: 1,750 r to the axilla; 2,000 r to each supraclavicular port; 1,500 r to each chest wall port.

TABLE II: DOSE DELIVERED TO VARIOUS POINTS IN PHANTOM BY EACH FIELD WITH 250-KEVP TANGENTIAL TECHNIC

Position in Phantom	Medial Tangential 26 × 12 cm. Field; 55 cm. TSD; Per Cent of Surface Dose	Lateral Tangential 26 × 12 cm. Field 55 cm. TSD; Per Cent of Surface Dose	Supra-clavicular 14.5 × 16 cm. Field 50 cm. TSD; Per Cent of Surface Dose
1	19	4	34
2 Internal	19	7	65
3 mammary	26	10	29
4	34	11	19
5	35	13	16
6 Mid-neck	7	3	10
7 Supraclavicular	22	10	59
8 Apex of	17	7	89
9 axilla	25	7	65
10	7	7	37
11 Posterior	11	12	34
12 lung	9	12	26
13	8	12	20
14	13	8	50
15 Medial	13	12	31
16 lung	11	11	23
17	10	12	17
18	25	11	32
19 Lateral	26	18	24
20 lung	30	20	21
21	22	26	21
22	40	11	35
23 Anterior	40	20	27
24 lung	38	28	20
25	31	31	13
26 Base of	10	21	11
27 lung	21	26	10
28 Apex of lung	26	7	43

TABLE III: DOSE DELIVERED TO VARIOUS POINTS IN PHANTOM BY EACH FIELD WITH 1,000-KEVP TANGENTIAL TECHNIC

Position in Phantom	Medial Tangential 26 × 12 cm. Field; 100 cm. TSD; Per Cent of Surface Dose	Lateral Tangential 26 × 12 cm. Field; 100 cm. TSD; Per Cent of Surface Dose	Supra-clavicular 16 × 18.5 cm. Field; 70 cm. TSD; Per Cent of Surface Dose
1	39	10	78
2 Internal	34	11	25
3 mammary	52	16	52
4	51	32	45
5	48	23	40
6 Mid-neck	9	6	101
7 Supraclavicular	9	11	88
8 Apex of	29	19	91
9 axilla	39	16	92
10	7	10	49
11 Posterior	10	13	54
12 lung	9	11	46
13	6	9	38
14	11	12	67
15 Medial	11	13	58
16 lung	8	8	45
17	8	8	39
18	29	14	66
19 Lateral	33	20	50
20 lung	40	33	43
21	18	16	37
22	55	24	59
23 Anterior	55	46	51
24 lung	57	39	41
25	50	22	30
26 Base of	11	11	29
27 lung	20	15	25
28 Apex of lung	39	13	83

ionization chambers were taped on the surface of the phantom. To determine whether discrepancies exist between measurements in patients and the phantom, similar surface measurements were done on three patients. Figure 2 demonstrates the positions of the chambers on the patient for a 250-kevp medial tangential field set-up before bolus was put in place.

RESULTS

The total amount delivered to each position within the phantom for a designated tissue dose by each technic is shown in Table I. Both the average total dose and the range are given in the table. In order to facilitate visualization of dose distribution, the doses at various points are presented in Figure 3. Each chamber position is represented by a dot; the number next to the dot is the measured dose expressed in hundreds of roentgens except where it was found to be less than 600 r.

Technic I: 250-kevp Tangential: For a calculated dose of 4,000 r delivered to the intersection of the central axes of the three beams, the 250-kevp tangential technic delivered approximately 1,900 to 2,800 r to the internal mammary area at a depth of 4 cm. from the skin surface, 2,900 to 3,400 r to the apex of the axilla and supraclavicular area, and 1,300 to 3,100 r to the lungs (Table I; Fig. 3).

If we analyze the contributions to each anatomic site by the individual radiation

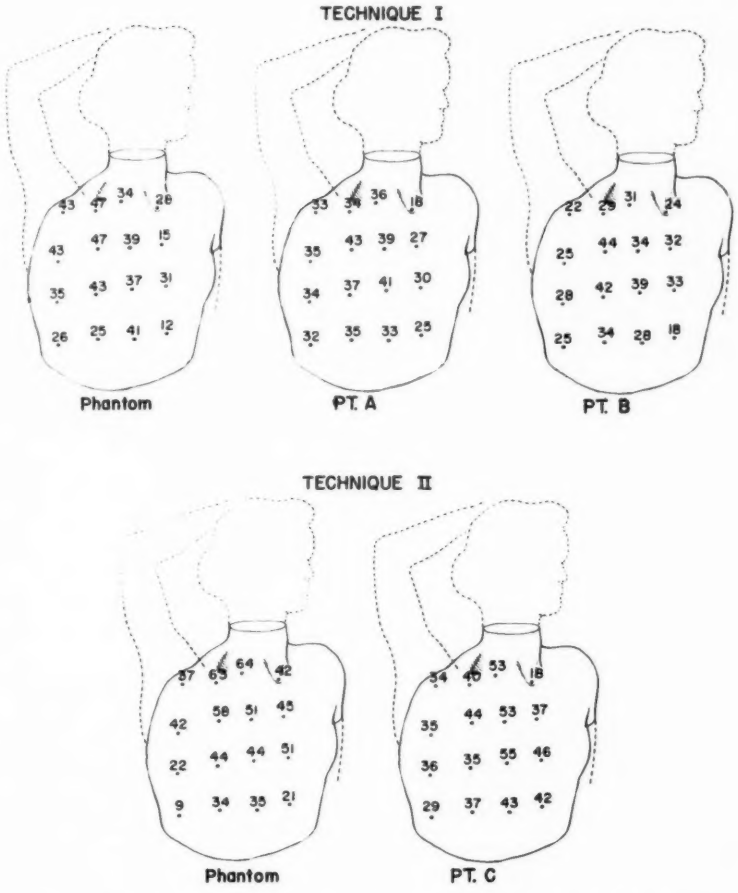

Fig. 4. Dose in hundreds of roentgens measured on the phantom and on patients, A, B, and C.
Technic I: Three-field tangential; 250 kevp, 2.0 mm. Cu h.v.l., planned tissue dose 4,000 r.
Technic II: Three-field tangential; 1,000 kevp, 3.4 mm. Pb h.v.l., planned tissue dose 5,000 r.

fields (Table II), the supraclavicular field is found to have contributed a high proportion of radiation to the supraclavicular area, the upper internal mammary region, and the apex of the axilla. The medial tangential field contributed a fairly large quantity to the lower internal mammary area. The lateral tangential field contributed something to the supraclavicular, axillary, and internal mammary areas. All three fields, especially the supraclavicular, delivered some radiation to the lungs, chiefly the upper and anterior portion.

Skin doses on the chest wall, measured both in patient and phantom, are presented in Figure 4. The dose varied from 1,200 to 4,700 r. The uneven distribution of the radiation was due in part to the fact that the twelve peripheral points were at the very margin of the treatment field and, therefore, the dose delivered was erratic. The different distribution of skin dose in the patients and phantom may also be due to variations in the curvature of the sternum. It can be seen that the calculated dose, 4,000 r, and the measured dose

TABLE IV: DOSE DELIVERY TO VARIOUS POINTS IN PHANTOM BY EACH FIELD WITH THREE-FIELD DIRECT-PORTAL TECHNIC

Position in Phantom		Internal Mammary 15 × 8 cm. Field; 70 cm. TSD; Per Cent of Surface Dose	Anterior Supraclavicular 13 × 15 cm. Field; 70 cm. TSD; Per Cent of Surface Dose	Posterior Supraclavicular 13 × 15 cm. Field; 70 cm. TSD; Per Cent of Surface Dose
1	Internal mammary	75	86	34
2		74	20	22
3		82	5	5
4		83	2	2
5		73	...	...
6	Mid-neck	...	82	62
7	Supraclavicular	...	70	86
8	Apex of axilla	...	59	63
9		13	82	49
10	Posterior lung	58	8	11
11		32	5	5
12		40	...	...
13		34	...	...
14	Medial lung	54	9	8
15		56	5	7
16		51	...	...
17		29	...	...
18	Lateral lung	15	12	12
19		13	5	4
20		14	...	...
21		...	...	...
22	Anterior lung	69	10	15
23		71	5	4
24		72	...	...
25		...	...	...
26	Base of lung	...	...	...
27		...	...	...
28	Apex of lung	55	20	24

for the central points agreed very well for both patient and phantom.

Technic II: 1,000 kevp Tangential: For a calculated tissue dose of 5,000 r the tangential technic at 1,000 kevp delivered 3,600 to 4,100 r to the internal mammary area, 3,300 to 4,500 r to the apex of the axilla and the supraclavicular area, and 1,600 to 4,900 r to the lungs (Table I; Fig. 3).

The contribution of the irradiation fields to each anatomic site was similar to that of the 250 kevp tangential technic except that the per cent depth dose was considerably higher (Table III). The skin dose on the chest wall (Fig. 4) ranged from 900 to 6,300 r, depending on the position of the ionization chambers. This variation was due to factors similar to those discussed under *Technic I*.

Technic III: Three-Field Direct-Portal: For an intended dose of 3,500 r, the three-field direct-portal technic delivered 3,300 to 7,000 r to the internal mammary nodes, 3,600 to 4,600 r to the apex of the axilla and supraclavicular region. The apex of the lung, which underlies the opposing anterior and posterior supraclavicular fields, received 3,900 r. The medial lung tissue beneath the internal mammary field received 1,300 to 3,000 r. The doses to the lateral lung tissue and base of the lung were negligible (Table I; Fig. 3).

Table IV shows the depth dose in relation to the surface dose for each field. The internal mammary field received approximately 78 r at a depth of 4 cm. per 100 r skin dose. This port also contributed heavily to the irradiation of the anteromedial lung. At some points, the lung dose was almost as high as that of the internal mammary area.

The skin doses were measured on the phantom at the center of each field. The dose to the internal mammary field was 4,700 r; to the posterior and anterior supraclavicular fields 2,600 and 2,900 r, respectively.

Technic IV: Five-Field Direct-Portal: As can be seen in Table I the five-field direct-portal technic delivered 1,500 to 4,000 r to the internal mammary region, 3,500 to 4,000 r to the apex of the axilla and supraclavicular area, and 1,100 to 4,000 r to the lungs. Table V shows the contribution of doses by each field. It can be seen that with this technic the axillary portal delivered additional radiation to the axilla, supraclavicular area, and upper lung. The low-voltage chest wall portals delivered a fairly large quantity of radiation to the lung.

The surface doses measured on the phantom were 2,400 and 2,200 r to the anterior and posterior supraclavicular fields, respectively, and 2,400 r to the axillary port.

TABLE V: DOSE DELIVERED TO VARIOUS POINTS IN PHANTOM BY EACH FIELD WITH FIVE-FIELD DIRECT-PORTAL TECHNIC

Position in Phantom	250 kvp; 2.0 mm. Cu h.v.l.			120 kvp; 3.4 mm. Al h.v.l.	
	Anterior Supraclavicular 13 × 15 cm. Field 50 cm. TSD Per Cent of Air Dose	Posterior Supraclavicular 13 × 15 cm. Field 50 cm. TSD Per Cent of Air Dose	Axillary 10 × 10 cm. Field 50 cm. TSD Per Cent of Air Dose	Medial Chest Wall 14 × 10 cm. Field 30 cm. TSD Per Cent of Air Dose	Lateral Chest Wall 18 × 10 cm. Field 30 cm. TSD Per Cent of Air Dose
1	71	28	19	22	4
2 Internal	58	45	27	29	11
3 mammary	10	15	7	39	21
4	5	5	7	44	26
5	...	...	...	44	34
6 Mid-neck	64	47	16	...	...
7 Supraclavicular	71	64	22	...	...
8 Apex of	69	52	15	...	...
9 axilla	72	42	36	7	5
10	17	27	52	17	8
11 Posterior	9	6	59	20	29
12 lung	...	...	10	21	35
13	...	...	...	20	36
14	14	24	43	21	18
15 Medial	8	7	20	27	30
16 lung	...	...	9	26	34
17	...	...	...	23	35
18	24	...	50	22	20
19 Lateral	8	6	66	21	36
20 lung	...	...	11	25	49
21	...	...	...	27	53
22	18	22	26	34	26
23 Anterial	6	5	23	37	35
24 lung	...	...	6	44	42
25	...	...	...	45	46
26 Base of	...	...	...	27	49
27 lung	...	...	...	44	45
28 Apex of lung	60	38	37	26	9

DISCUSSION

I. *Dose to Tumor-Bearing Areas:* An irradiation technic should be designed to deliver an adequate dose to the tumor-bearing areas. The 1,000-kevp tangential technic provided a high and evenly distributed tissue dose to all the possible tumor-bearing areas. With the 250-kevp tangential technic, the irradiation of the chest wall, axilla, and supraclavicular areas was satisfactory, but the amount of radiation delivered to the internal mammary area appeared low. It should be noted that the internal mammary measurements were made at a depth of 4 cm. below the skin. This is the maximum depth at which these nodes are likely to lie. On the other hand, the phantom used contained no bone. Nodes underlying bone would therefore receive a somewhat lower dose of radiation than measured in the phantom. In the case of 1,000-kevp x-rays, the overlying bone does not materially affect the dose delivered. Electrons emitted from the bone do not have a sufficient range to reach these nodes and hence cause no increase in dosage.

The standard radical mastectomy does not attempt to eradicate surgically the spread of tumor to the internal mammary and the supraclavicular areas. Since the incidence of metastases to the internal mammary nodes has been reported as approximately 33 per cent (4), the three-field direct-portal technic was developed to deliver adequate doses to the internal mammary and supraclavicular areas. This study revealed that a dose range of 3,300 to 7,000 r was delivered to the internal mammary chain. The hot spot of 7,000 r was at the junction of supraclavicular and internal mammary portals. These

fields have subsequently been separated by 1 cm. to eradicate this. The apex of the axilla and supraclavicular fields received 4,100 to 4,600 r (Table I).

The five-field direct-portal technic, used at Memorial Hospital prior to 1949, has been included in this study for the sake of comparison. It is obvious that with this technic distribution of radiation was uneven and, particularly, irradiation to the internal mammary areas was inadequate because the low voltage and short target-skin distance produced a low percentage depth dose.

II. *Dose to the Lung:* Examination of the data indicates that, of the four methods studied, the 250-kevp tangential technic delivered the least radiation to the lung. When 1,000 kevp was used instead of the 250 kevp, the lung dose was higher. The anterior lung received 4,900 r, which was the highest dose to the lung from any of the technics. This, however, was delivered in a period of five to six weeks. With the three-field direct-portal technic the chest wall was not irradiated, and the radiation to the lower lateral lung was therefore negligible, but the dose to the upper and medial lung was found to be appreciable. On the other hand, the five-field direct-portal technic delivered approximately 4,000 r in two and one-half weeks to the apex of the lung.

While it is clearly recognized that such factors as age of the patient, pre-existing disease, and secondary infection affect the incidence and severity of radiation pneumonitis, the volume irradiated and the time-dosage relationship remain the paramount factors in the development of this syndrome (1, 5). In this respect, it is interesting to note that the 250-kevp tangential technic produced the lowest incidence of pneumonitis (7 per cent), while the five-field direct-portal technic appears to have produced the highest incidence (60 per cent), primarily in the upper lung field. On the other hand, the incidence of pneumonitis secondary to the 1,000-kevp tangential technic was 25 per cent. In the cases studied, the pneumonitis following this procedure was located anteriorly (1). At the present time the figures are not available for the incidence of pneumonitis resulting from the three-field direct-portal technic and this is currently being investigated.

III. *General Comments:* The tangential technic, both the 250 kevp and 1,000 kevp energies, required special accessory equipment, such as protractor, special cone or beam director, and tilting table. These are not necessary for the direct portal technic. The set-up time is shorter for the direct-portal than for the tangential technics. Clinically, however, patients tolerated the 1,000-kevp tangential technic best in terms of both skin tolerance and systemic reaction. Because of this, it was possible to continue the irradiation to a higher dosage level. For this reason it was felt that the additional effort and time required would appear to be worthwhile.

Each technic has its advantages and disadvantages. From the data obtained in this study, the 1,000-kevp tangential technic appears to be the most satisfactory of the four methods studied. The tissue dose was highest throughout the possible tumor-bearing areas and the distribution of radiation was relatively even. In the final analysis, the information obtained from this study must be correlated with the clinical end-results to determine which is the best radiotherapeutic technic for postoperative and inoperable carcinoma of the breast.

SUMMARY

Ionization chamber measurements were made in various positions within and on the surface of a phantom woman, with four irradiation technics for carcinoma of the breast: 250-kevp tangential, 1,000-kevp tangential, three-field direct-portal, and five-field direct-portal. Surface dose measurements were also made on patients for the 250-kevp and 1,000-kevp technics. These data are presented both as depth doses in per cent of surface dose for each portal and in total doses for an attempted tissue dose of a particular technic.

The advantages and disadvantages of the four technics of irradiation are discussed. The 1,000-kevp tangential technic appeared to be the most satisfactory among the methods studied because of its more even distribution of radiation and higher tissue dose delivered.

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The authors also take pleasure in acknowledging their indebtedness to Miss Elizabeth Focht and Dr. Arvin S. Glicksman for their cooperation and assistance in this study.

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SUMMARIO IN INTERLINGUA

Distribution del Dosage in Quatro Technicas de Irradiation pro le Tractamento de Cancere Mammari

Mesurationes a camera de ionisation esseva effectuate in varie positiones intra e al superficie de un femina phantoma con le uso de quatro technicas de irradiation therapeutic pro carcinoma mammari. Le technicas esseva: tangential a 250 kevp, tangential a 1.000 kevp, a portal directe tricampal, e a portal directe quinquecampal. Mesurationes de dosage al superficie esseva etiam effectuate in patientes in le caso del technicas a 250 e 1.000 kevp. Le datos obtenite es presentate in le forma de (1) doses de profundor in pro cento de dosage al superficie pro omne portal e (2) doses total pro desirate doses de histo con un technica particular.

Cata un del technicas ha su avantages e disavantages. Super le base del datos obtenite in le presente studio, le technica tangential a 1.000 kevp pare esser le plus satisfacente del quatro technicas considerate. In iste technica, le dose de histo esseva le plus alte in omne partes del area in que tumores pote esser presente, e le distribution del radiation esseva relativemente uniforme. Ab le puncto de vista clinic, le patientes tolerava le technica tangential a 1.000 kevp le melio, a judicar tanto per le tolerantia cutanee como etiam per le reactiones systemic. In le ultime analyse, le informationes obtenite in iste studio debe esser correlationate con le resultatos clinic final pro determinar le qual es le medior technica radiotherapeutic pro le tractamento postoperatori de carcinoma mammari e de casos inoperabile.

EDITORIAL

Operations Research and Optimal Radiology

Operations research is a novel approach to the problem of making sound decisions in complex matters. Conceived during the last war by scientists helping the war effort, it has proved its usefulness in many fields, as different as hunting enemy submarines and determining optimal rates of industrial production. Very briefly, the operations research approach consists in determining one's objectives, selecting meaningful measures of achievement, formulating a mathematical model of the problem to show both the variables under control and those not subject to control, and indicating the results of alternate courses of action (2).

Problems of roentgen diagnosis are many, but they do not greatly resemble those of finding hidden submersibles, except for the trying necessity of making important decisions when information available is incomplete or uncertain. The art of diagnosis is the art of evaluating equivocal evidence. Problems of patients with partial proof provide the pitfalls and pleasures of roentgen iconography, the pride of predictions come true, and the pains, and lessons, of insight by hindsight. If it were otherwise, it would not be the same; if roentgen findings would always lead to conclusions that are obvious and certain, examining patients would be no more interesting than examining metal castings.

Since the normal merges imperceptibly with the abnormal in size, shape, structure, and function, examinations in clinical medicine cannot make sharp distinctions. The body weight, the blood hemoglobin level, or a chest roentgenogram reveal the obviously healthy and the obviously sick but leave us with the puzzle of a third group, those with equivocal findings. Some aspects of the problem of "borderline" observations are shown as simple numerical concepts, such as *sensitivity* and *specificity* of a given method, and others. Since diagnoses are predictions, only future events can make them true or false; *true positive*, *false positive*, *true negative* and *false negative* refer to the way a diagnostic opinion fares in the light of later findings; a "positive" reading in a patient who turns out to have been "positive" constitutes a *true positive*. Diagnostic statements are confirmed by events, not authority.

A clinical test, or sign, is said to be *sensitive* if it helps find most of those affected among those examined—it yields few *false negatives;* unless such a test is also *specific*, it may include among the sick many who are not (many *false positives*). Roentgen signs of pulmonary emphysema in aging people could be said to be *sensitive*, but not very *specific;* we miss few of those who have the disease, but may suspect many who do not have it. A test is called *wholly specific* (3) if it is positive only in those having a certain disease—it gives no *false positives;* unless it is *sensitive* at the same time, such a test may give many *false negatives*. Subperiosteal bone resorption in the phalanges of the hands is a *specific*, but not very *sensitive* roentgen sign of hyperparathyroidism; it is not seen in other conditions, but, like any other type of bone involvement in this disease, it is absent in many of those affected. An ideal test, or sign, is one that is always positive in the presence of the condition looked for, but never otherwise. There are not many such signs in radiology; the only examples that come to mind are those in which the findings constitute the diagnosis, such as dislocations or simple malformations.

The attitude of an observer confronted with doubtful findings can be "normal, until proved otherwise," or the converse;

one has to decide between waiting for further proof and seeking further proof, and in real life the man who always wants better evidence is not always the better man. Developing a sound attitude is part of growing up in medicine; by itself, an honest determination to avoid being wrong will not work, for several reasons. It ignores the problem. It does not build character, since a desire to avoid error may lead to avoiding responsibility. Finally infallibility in diagnosis could be had, if at all, only at the cost of a wasteful disproportion between effort and return.

Simple truths appear obvious, after they have been pointed out. An unusually lucid article on evaluating health screening procedures by a physician experienced in the technics of operations research (1) has documented such a simple truth: different clinical situations are different, and the same approach cannot be best in all of them. What one ought to do will depend upon what one wants to avoid as well as what one wants to accomplish (*false positives* vs. *false negatives*). Sometimes we want to find all those affected among those examined (no *false negatives*), as in looking for typhoid carriers among food handlers; in this instance *false positives* are not a calamity and *true negatives* are of no interest. In selecting personnel for a hospital, or in screening airmen for a physically demanding mission, *true negatives* are important and false negatives are to be avoided; *true positives* and *false positives* are of little importance. Tests whose results may lead to criminal prosecution ought to be designed to avoid *false positives*—in keeping with the principle of "innocent until *proved* otherwise"—even at the cost of some *false negatives*. With the help of a simple formula and a few graphs, Blumberg shows that what he calls "optimum screening level" of a test depends upon the value attached to the different test results.

This formula is not numerically applicable to roentgen diagnosis, but his method is of great help in thinking through the problem of interpreting borderline or minimal findings; one might call this "the radiologist's dilemma": *overreading* vs. *underreading*. Blumberg's approach shows persuasively, if persuasion be needed, that what could be referred to as an observer's "reading level" (by analogy with the "screening level" of quantitative tests), assuming it could be properly defined, could not be sound or unsound by itself, but only in a given clinical context; *overreading* in one group of cases can be as bad as *underreading* is in others. With structures that show a wide normal range, or are rarely diseased, or both, such as the thymus gland in infants, *overreading* might lead to much harm and little good. In a different group of cases, as in patients with certain well defined brain symptoms and properly placed "minimal" roentgen findings—"slight" blunting of one anterior clinoid process; enlargement of one foramen spinosum; loss of lime in the tip of one petrous pyramid—*underreading* and waiting for more convincing signs will do harm and little good, since more convincing roentgen signs may never develop.

What constitutes a sound approach in a patient with uncertain findings will depend upon other factors, many of them; the condition of the patient is as important as the condition one suspects. Doubtful findings in the gastric antrum of a patient past middle age with a recent onset of symptoms, if seen in a man in good health, will be reported—perhaps within the hour—as "carcinoma, until proved otherwise"; a less emphatic, and less urgent, report may make one responsible for a delay in obtaining reliable evidence. Similar roentgen findings in a patient seventy years of age, with an impaired myocardium, might be reported as "uncertain findings, possibly carcinoma of the stomach;" a too great sense of urgency in this case may not be in the best interest of the patient. Obviously, the final judgment of the seriousness of the problem must be left to the referring physician.

Reporting, no less than observing and inferring, is part of roentgen diagnosis; it would be a contradiction in terms to say

of someone: "He is a good worker; only his reports are not too careful." If in cases falling under his competence the radiologist has a material influence in shaping clinical decisions—a pleasingly prevailing practice—then examining the consequences of his opinions becomes an important part of his responsibility as a clinical consultant.

According to William James, a great scientist *and* philosopher, philosophy is nothing but an unusually obstinate effort to think clearly; in this sense most radiologists are practicing philosophers. The approach of "operations research" promotes clarity by stressing, among others, the need for meaningful standards of performance and for examining the consequences of alternate courses of action. Since this is what responsible roentgen reporting rests upon, one could assert, alliteratively, that the approach of operations research often results in optimal radiology.

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Cumulative Index IV

With the publication of the first *Cumulative Index* of RADIOLOGY in 1943, there was a question in the minds of some as to its acceptance. Would the demand for it be sufficient to justify the labor and the expense involved? That question happily was soon resolved, and the publication of *Cumulative Index IV*, covering the years 1953–1957, is announced with the assurance that it will be enthusiastically welcomed. That it runs to a few more pages than its earliest predecessor, which covered a period four times as long, is evidence of the expansion of radiology as a specialty over the intervening years, and the concomitant growth of the journal.

The value of any scientific text is enhanced immeasurably by adequate indexing, and for a periodical made up of the contributions of a large number of writers covering diverse aspects in even a single field an index becomes indispensable. Its usefulness—as well as the work of preparation—is multiplied in the case of a journal such as RADIOLOGY, which contains, in addition to a wide variety of original papers, an Abstract Section based upon the world literature.

The ramifications of radiology are manifold. It overlaps every specialty and finds an important place in general medicine. Its literature is not confined to the twenty or more strictly "radiological journals." It is of concern to the orthopedist, the urologist, the pediatrician, the obstetrician, and a host of others, who look to their own journals to cover this aspect of their practice. In the Abstract pages of RADIOLOGY the best of these papers have been summarized. To locate an article of interest in this mass of material twenty or thirty months after its publication would tax even the most retentive memory, and the task of assembling contributions on any given subject—one of the isotopes perhaps, or some newer diagnostic technic—would be a formidable undertaking.

In the ten volumes covered by the present Index there appear over 2,000 pages of Abstracts. At between three and four abstracts to a page, this means nearly 7,500 papers representative of radiology in its many phases, and to these must be added some 925 original contributions, as well as editorials, book reviews, and announcements of interest. Are you looking for a needle of immediate interest in this haystack of radiologic literature? We commend to you RADIOLOGY's *Cumulative Index IV*.

OREGON RADIOLOGICAL SOCIETY

The Oregon Radiological Society has elected the following officers to serve for the ensuing year: President, Clay Racely, M.D., Eugene; President-Elect, C. V. Allen, M.D., Portland; Secretary-Treasurer, Barbara J. Radmore, M.D., 1162 Willamette St., Eugene; Executive Committeeman, J. Richard Raines, M.D., Portland; Councilor to the American College of Radiology, William Burton, M.D., Portland; Alternate Councilor, James Haworth, M.D., Salem.

WEST VIRGINIA RADIOLOGICAL SOCIETY

At the recent meeting of the West Virginia Radiological Society, at The Greenbrier, White Sulphur Springs, the following were elected to office: President, John D. H. Wilson, M.D., Clarksburg; Vice-President, Everett W. Squire, M.D., Charleston; Executive Committee Members, James L. Patterson, M.D., Logan, H. A. Shaffer, M.D., Morgantown, W. Paul Elkin, M.D., Charleston; Councilor to the American College of Radiology, John D. H. Wilson, M.D., Alternate Councilor, J. L. Curry, M.D.; Secretary-Treasurer, Karl J. Myers, M.D., The Myers Clinic-Broaddus Hospital, Philippi. The Immediate Past President is Dr. W. Paul Elkin.

THIRD INTERNATIONAL CONGRESS ON PHOTOBIOLOGY

The Third International Congress on Photobiology will be held in Copenhagen, July 31–Aug. 5, 1960. In honor of the hundredth anniversary of the birth of Niels R. Finsen, this will be known as the Finsen Memorial Congress. The President of the Congress is Børge Chr. Christensen, M.D., D.Sc., of the Finsen Memorial Hospital, Copenhagen, Denmark; the Secretary-General is Dr. techn. B. Buchmann, Biofysisk Laboratorium, Juliane Mariesvej 30, Copenhagen.

The program will consist in contributed papers and a series of symposia on: (1) biological action spectra; (2) initial mechanisms involved in radiation effects; (3) phototherapy; (4) photoreceptors in aquatic organisms; (5) the results of the Third International Geophysical Year in regard to radiation.

Inquiries may be addressed to the President or to the Secretary-General of the Congress.

NOTE TO EDITOR

The Editor is in receipt of a note from a member of the Radiological Society of North America which he is glad to publish here.

"This note is to call attention to a substance which has been found very suitable for skin marking in radiation therapy. This is a solution called X-Ray Guide. It is similar to Princess Pat Liquid Liptone, which was also found to be a satisfactory skin marking substance, but very expensive. X-Ray Guide is available from Princess Pat, 2709 S. Wells St., Chicago, Ill. The manufacturer will be pleased to know the reaction of radiologists to this product."

MILFORD D. SCHULZ, M.D.
Boston, Mass.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

DENTAL ROENTGENOLOGY. By LEROY M. ENNIS, D.D.S., F.D.S., R.C.S. (Eng.), Chairman of the Department of Roentgenology, and Professor of Roentgenology, The Thomas W. Evans Museum and Institute, School of Dentistry, University of Pennsylvania; Chairman of the Department of Oral Roentgenology, and Professor of Oral Roentgenology, The Graduate School of Medicine, University of Pennsylvania; Consultant in Dental Roentgenology, United States Navy, United States Army, and The United States Veterans Administration Hospital, Coatesville, Pennsylvania; and HARRISON M. BERRY, JR., D.D.S., M.Sc., Professor of Roentgenology, The Thomas W. Evans Museum and Institute, School of Dentistry, University of Pennsylvania; Associate Professor of Oral Roentgenology, Graduate School of Medicine, University of Pennsylvania; Director, Courses in Oral Hygiene, School of Dentistry, University of Pennsylvania; Chief, Dental Roentgenology, Philadelphia General Hospital; Area Consultant, Dentistry, U. S. Veterans Administration; Civilian Consultant in Dental Roentgenology, U. S. Naval Hospital, Philadelphia, and Valley Forge Army Hospital. A volume of 608 pages, with 1,282 illustrations. Published by Lea & Febiger, Philadelphia 6, Penna., 5th ed., 1959. Price $15.00.

1958 HIGHLIGHTS OF PROGRESS IN RESEARCH ON CANCER: ITEMS OF INTEREST ON RESEARCH STUDIES CONDUCTED AND SUPPORTED JANUARY THROUGH DECEMBER 1958 BY THE NATIONAL CANCER INSTITUTE. Prepared by the NATIONAL CANCER INSTITUTE. Public Health Service Publication No. 671. A monograph of 46 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 1959. Price 25 cents.

CONTEMPORARY EQUIPMENT FOR WORK WITH RADIOACTIVE ISOTOPES: COLLECTED REPORTS. Translated from the Russian. Supplement No. 5 of the Soviet Journal of Atomic Energy, 1958. A monograph of 66 pages, with 36 figures. Published by Consultants Bureau, Inc., 227 West 17th St., New York 11, N. Y., 1959. Price $15.00.

DAS RÖNTGENSCHICHTBILD. By Prof. Dr. med. A. GEBAUER, Frankfurt am Main, Doz. Dr. med. E. MUNTEAN, Graz, Prof. Dr. med. E. STUTZ, Freiburg i. Br., and Prof. Dr. med. H. VIETEN, Düsseldorf. A volume of 454 pages, with illustrations on 699 figures. Published by Georg Thieme, Herdweg 63, (14a) Stuttgart, Germany, 1959. Distributed in United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 148.—($35.25).

EINFÜHRUNG IN DIE RÖNTGENDIAGNOSTIK. By Prof. Dr. U. COCCHI, ZÜRICH, and Priv.-Doz. Dr. P. THURN, Bonn. A volume of 340 pages, with 547 illustrations on 419 figures. Published by Georg Thieme, Herdweg 63, (14a) Stuttgart, Germany, 1959. Distributed in United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 49.50.—($11.80).

DIE WIRBELSÄULENLEIDEN UND IHRE DIFFERENTIALDIAGNOSE. By Prof. Dr. J. E. W. BROCHER, Genf. Fortschr. a. d. Geb. d. Röntgenstrahlen, Ergänzungsband 68. A volume of 458 pages, with 639 illustrations on 287 figures. Published by Georg Thieme, Herdweg 63, (14a) Stuttgart, Germany, 2d ed., 1959. Distributed in United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 128.—($30.50); to subscribers to Fortschritte, DM 115.20—($27.45).

KLINIK UND PRAXIS DER UROLOGIE: KLINIK, INDIKATION, DIAGNOSTIK, OPERATIVE UND INSTRUMENTELLE EINGRIFFE, NACHBEHANDLUNG. BAND I. By Prof. Dr. WERNER STAEHLER, Leiter der Urologischen Abteilung der Chirurgischen Universitätsklinik Tübingen. With a Foreword by Prof. Dr. Th. Naegeli, Tübingen. A volume of 892 pages, with 1,034 figures, some in color. Published by Georg Thieme, Herdweg 63, (14a) Stuttgart, Germany, 1959. Distributed in United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 240.—($57.15).

DIE PHLEBOGRAPHIE DER UNTEREN EXTREMITÄT. By Dr. ROBERT MAY, Innsbruck, and Dr. RAIMUND NISSL, Innsbruck. Fortschr. a. d. Geb. d. Röntgenstrahlen, Ergänzungsband 84. A volume of 198 pages, with 395 illustrations on 250 figures. Published by Georg Thieme, Herdweg 63, (14a) Stuttgart, Germany, 1959. Distributed in United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 75.—($17.85); to subscribers to Fortschritte, DM 67.50—($16.05).

DIE STREIFENATELEKTASEN DER LUNGE. By Priv.-Doz. Dr. med. FRIEDRICH HEUCK, Oberarzt der Röntgenstationen der Medizinischen Universitäts-Klinik Kiel. Heft 7, Zwanglose Abhandlungen aus dem Gebiet der normalen und pathologischen Anatomie. Edited by Prof. Dr. W. Bargmann, Direktor des Anatomischen Instituts der Universität Kiel, and Prof. Dr. W. Doerr, Direktor des Pathologischen Instituts der Universität Kiel. A monograph of 108 pages, with 136 illustrations on 64 figures. Published by Georg Thieme, Herdweg 63, (14a) Stuttgart, Germany, 1959. Distributed in United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 32.—($7.60); to subscribers DM 25.60—($6.10).

DAS DIAGNOSTISCHE PNEUMOPERITONEUM. By Prof. Dr. med. A. GEBAUER, Frankfurt am Main. With a Foreword by Prof. Dr. F. Hoff, Direktor der I. Medizinischen Universitätsklinik, Frankfurt am Main. A monograph of 70 pages, with 78 figures. Published by Georg Thieme, Herdweg 63, (14a) Stuttgart, Germany, 1959. Distributed in United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 18.—($4.30).

Book Reviews

THE YEAR BOOK OF RADIOLOGY (1958–1959 YEAR BOOK SERIES). RADIOLOGIC DIAGNOSIS. Edited by JOHN FLOYD HOLT, M.D., Professor, Department of Radiology, University of Michigan, and FRED JENNER HODGES, M.D., Professor and Chairman, Department of Radiology, University of Michigan. RADIATION THERAPY. Edited by HAROLD W. JACOX, M.D., Professor of Radiology, College of Physicians and Surgeons, Columbia University; Chief, Radiation Therapy Division, Radiologic Service, Presbyterian Hospital, New York City, and MORTON M. KLIGERMAN, M.D., Professor of Radiology and Chairman of the Department of Radiology, Yale University School of Medicine; Director of Radiology, Grace-New Haven Community Hospital. A volume of 448 pages, with 336 figures. Published by the Year Book Publishers, Inc., Chicago, Ill., 1958. Price $10.00.

The high degree of excellence that one has come to expect in the Year Book of Radiology is maintained

in the current volume, which covers material appearing in the literature in 1957 and 1958. The selection of papers for abstracting has been carefully done, with an eye especially to the newer aspects of the specialty and the increased emphasis upon more familiar phases.

The Introductions by the editors to the sections on Diagnosis and Radiation Therapy, respectively, are worthy of special attention, summing up succinctly the current trends in these fields. The abstracts that follow, well illustrated and pointedly annotated, fill out the picture.

LEHRBUCH DER STRAHLENHEILKUNDE: BEHANDLUNG MIT RÖNTGENSTRAHLEN UND RADIOAKTIVEN SUBSTANZEN. By RENÉ DU MESNIL DE ROCHEMONT, o.ö. Professor für Medizinische Strahlenkunde und Direktor der Strahlenklinik und -Poliklinik der Universität Marburg. With the assistance of Dr. H. J. FIEBELKORN, Prof. Dr. E. H. GRAUL, and Doz. Dr. E. SCHERER, Oberärzte der Klinik. A volume of 764 pages, with 266 figures, including 5 color plates, and 18 tables. Published by Ferdinand Enke, Hasenbergsteige 3, (14 a) Stuttgart-W, Germany, 1958. Price DM 113.—, paper-bound; DM 119.—, cloth-bound.

The first part of this book deals mainly with the physical aspects of the application of radiation in therapy, including primary interaction of x-rays with matter; x-ray circuits; dosimetry; means of teletherapy such as rotation, pendulum, and grid modifications; and the use of radioactive isotopes. The section closes with a consideration of the choice of treatment for various types of malignant disease.

The second part of the book has radiation biology for its theme. The various "hit" theories are discussed. Actual radiation genetic problems, radiation biology of virus and genes, radiation reaction of cells and mitosis, radiation sensitivity of different cells, and time of application and fractionation effects are included in this section. A consideration of the biological basis of practical radiation therapy follows and a discussion of the biological effects of radiation finishes the section.

The third and last part of the book is devoted to the clinical aspects of therapy with x-rays and radioactive material. Treatment of inflammatory diseases, blood diseases, skin diseases, hypertrophic processes, benign and malignant tumors are discussed in detail. Clinical reports, suggested treatments, and statistical data are supplied in abundance.

The book is written in a flowing style. It contains a wealth of information, both physical and clinical, and its value is enhanced by the multitude of reference sources. The excellent illustrations are a definite asset. Not only is this volume a good textbook, but it is a valuable handbook for radiation therapists.

FORTY-FIFTH ANNUAL MEETING: COMMERCIAL EXHIBITS

The Commercial Exhibits Section constitutes a most important part of the Annual Meeting of the Radiological Society, bringing together in imposing array advances in equipment, media, protective devices, procedure, publications, etc. The following list of exhibits to be presented at the 1959 Meeting has been assembled by the Committee on Exhibits (Dr. John H. Gilmore, Chairman) as a guide for those planning to attend.

Abbott Laboratories, North Chicago, Ill. (Booth 76).

Ansco Division of General Aniline and Film Corporation, Binghamton, N. Y. (Booths 16 and 17): The Ansco exhibit will feature Ansco Bulkpak, the revolutionary new x-ray film package designed specifically for quantity users of medical x-ray films. Introduced in June, Bulkpak has been enthusiastically received by hospitals and other high-volume users of x-ray films because of the ease of handling which this new package affords. A built-in rip-strip tape facilitates easy opening. Both the shipping carton and individual pouches can be opened with the rip-strip tab.

In addition to Bulkpak the Ansco X-ray Sales Department will feature Monopak, the individually wrapped medical x-ray film, available in Ansco Nonscreen and Ansco High Speed films. Convention plans also call for the announcement of the new edition of Dr. Edith Quimby's booklet, "Dosage Calculations in Radium Therapy."

Ansco aids for the radiologist will be displayed.

Atomic Energy of Canada Ltd., Ottawa, Ont. (Booths 26 and 27): On exhibit will be the new Theratron C-II Cobalt-60 therapy unit, one of the eight cobalt 60 and caesium tele therapy equipments now marketed by Atomic Energy of Canada Limited. This intermediate-long treatment distance unit features full-range positioning and facilities for fixed and moving-beam technics, including an independently adjustable sourcehead; capacity for efficient outputs at intermediate or long treatment distances; a new, highly flexible 8-sided diaphragm, plus a full range of accessory devices for complete, reliable beam control.

A professional staff will be on hand to discuss which of the cobalt or caesium equipments, radioactive sources, or other products best meet individual requirements.

Automatic Seriograph Corporation, College Park, Md. (Booth 125): The Automatic Seriograph Corporation, a subsidiary of Litton Industries, Inc., will exhibit the Model 110 Automatic Seriograph, a rapid sequence cassette changer which works in conjunction with standard x-ray equipment. The Seriograph will automatically take up to twelve 11 × 14″ roentgenograms at preselected interval speeds of one-half second to over two seconds. It is especially designed for cerebral angiography, angiocardiography, or any study requiring a series of x-ray pictures at regular or irregular intervals.

Barnes-Hind Barium Products Company, Sunnyvale, Calif. (Booth 38): Barnes-Hind Barium Products Co. will exhibit their specially processed micronized barium sulfate, under the trademark "Barotrast."

The Pneumocolon will be demonstrated to show its effectiveness in the administration of Barotrast or air in colonic radiographic examinations.

Advance information will be distributed on "Clysodrast," a new type purgative for use in the preparation of the large bowel for radiographic study.

Bar-Ray Products, Inc., Brooklyn, N. Y. (Booths 105 and 106).

Bell-Craig Inc., New York, N. Y. (Booth 13): Bell-Craig Inc. will display samples of its complete line of radiopaque media consisting of micro and U.S.P. bariums (Baroloid, Ultrapaque and Raybar F.B.S.), cholagogues for duct demonstration in cholecystography (Neo-Cholex and Cholex), aqueous contrast solution for cholangiography and hysterosalpingography and an improved, disposable rectal catheter (Cly-Tips).

Buck X-Ograph Co., St. Louis, Mo. (Booths 91 and 92).

Carr Corporation, Santa Monica, Calif. (Booths 24 and 25): Carr Corporation will show a through-wall developing tank, featuring plumbing in front. It will also feature a new automatic dryer, which will dry film in five minutes.

Coca-Cola Co., Atlanta, Ga. (Booth 7): Ice-cold Coca-Cola will be served through the courtesy and co-operation of the Coca-Cola Bottling Co., of Chicago, Inc., and The Coca-Cola Company.

Continental X-ray Corporation, Chicago, Ill. (Booths 114 and 115).

Coreco Research Corporation, New York, N. Y. (Booth 101): The Coret camera embodies the principle of electronic flash and constant automatic control of such factors as distance, aperture, field, and exposure. Now, for the first time, Coreco offers a completely automatic professional clinical camera purposely designed to achieve the ultimate in surface, intra-oral, and intra-tubular photography. Because of the simplicity of operation, even an inexperienced doctor or nurse can achieve consistently perfect color transparencies.

Dunlee Corporation, Chicago, Ill. (Booths 88 and 89): Dunlee Corporation will have on display a complete line of x-ray tube units, replacement inserts, and valve tubes. Featured in this year's display will be the new Dunlee 150-kvp over-table and under-table rotating anode shockproof x-ray tube housings.

E. I. duPont de Nemours & Company, Wilmington, Del. (Booths 57–60).

Eastman Kodak Company, Rochester, N. Y. (Booths 97, 98, 109, 110): The Eastman Kodak exhibit will show a new X-Omat Processor, Model M3. Smaller, more compact and lower in price than previous models, it delivers high quality radiographs in seven minutes. A display of Blue Brand and Royal Blue X-ray Films will be supplemented by a demonstration of various useful photographic visual aids which can be evolved from radiographs.

Eureka X-Ray Tube Corporation, Chicago, Ill. (Booth 83): Rotating anode x-ray tubes of 100 kvp to 150 kvp will be displayed along with representative stationary anode tubes and valve tubes. New rotating anode housings designed for table mounting to effect a substantial weight reduction of the table mechanism will also be shown. The new "Sapphire 150" Rotating Anode Unit will be featured.

Fairchild Camera and Instrument Corporation, Yonkers, N. Y. (Booths 69 and 70): Of special interest is the new Fairchild-Odelca 4 × 4 Ultra Speed In-Line camera. This camera is particularly adaptable for hospital admissions programs and industrial health programs, as well as other mass chest survey applications. It offers all the advantages of automatic film transport on 4 × 4 cut film at a cost only slightly higher than the Fairchild-Odelca 70-mm. camera.

C. B. Fleet Company, Inc., Lynchburg, Va. (Booth 116): *A Simplified, Safe and Satisfactory Method of Preparation for Barium Enema Studies* is the title of a clinical report of a recently concluded series of 250 cases. At Booth 116 an abstract of this report will be available, as well as personalized instructions for patient distribution.

Forsyth X-ray Corporation, Chicago, Ill. (Booth 71).

E. Fougera & Company, Hicksville, N. Y. (Booth 80): E. Fougera & Company is featuring Orabilex, a new oral contrast medium for cholecystography and cholangiography. Only recently marketed, Orabilex is rapidly becoming the agent of choice in these procedures. Published reports confirm the advantages originally ascribed to Orabilex. The standard six-capsule dose, lack of obscuring bowel opacities, greatly lowered incidence of side effects, and enhanced radiographic reliability in visualizing the gallbladder and biliary ducts are among these advantages. Descriptive material, clinical literature, comparative film studies, and clinical material will be available at Booth 80. Informed representatives will be on hand to answer your inquiries and service your requests.

Franklin X-Ray Corporation, Philadelphia, Penna. (Booth 100): The Franklin Model-A Headstand will be shown, providing a precision instrument for radiography of the skull; also a rapid film changer which will shift film at speeds of 1, 2, 4, or 6 per second. A sequence programmer automatically runs the changer at any preselected speed and time element.

General Electric Company, X-Ray Department, Milwaukee, Wisc. (Booths 30–36).

Gordon Consultants, Kent Cliffs, N. Y. (Booth 45): Gordon Consultants are exhibiting three items: (1) The latest model Gordon Universal Projector, considerably improved over last year's model, for far and near and high and low projection of x-ray films and all other materials except microscopic slides; (2) newest edition of the Gordon Pocket Stereoscope, now in use in over 150 medical institutions; (3) new light box with built-in shades.

Grune & Stratton, Inc., New York, N. Y. (Booth 40): Mr. Frank Kurzer will be on hand to show some of Grune & Stratton's newest titles in radiology, including such important works as Schmorl and Junghanns' *The Human Spine in Health and Disease;* Schobinger's *Intraosseous Venography;* Schinz' *Roentgendiagnostics, Progress Volume I;* Shilling's *Radiation Hazards;* Buschke's *Progress in Radiation Therapy;* Schäfer's *Pediatric Roentgenology;* Köhler's *Borderlands of the Normal and Early Pathologic in Skeletal Roentgenology;* Lacassagne's *Action of Radiation on Tissues;* as well as many other important new books which you are invited to inspect.

Halsey X-Ray Products, Inc., Brooklyn, N. Y. (Booths 102 and 103): The Halsey X-Ray Products exhibit will be aimed specifically at the radiation-conscious. Sixty per cent of the exhibit will be devoted to a revolutionary new protective material identified as Fabri-Plex. This material has an estimated life expectancy four times greater than that of the most popular previously used, while adding comfort and aesthetic features not heretofore available.

Whether customer, potential customer, or just curious, all are cordially invited to visit Booths 102 and 103. In addition to the above, warranty and guarantee bonds will be available for examination on Halsey's complete line of radiographic cassettes.

Heico, Inc., Stroudsburg, Penna. (Booths 65 and 66): The Heico exhibit will include their conventional top-loading and through-the-wall models of x-ray dryers, which are in use in medical institutions throughout the United States and Canada. In addition, a piece of equipment just out of research, demonstrating a new processing technic, will be unveiled for the first time.

Paul B. Hoeber, Inc., New York, N. Y. (Booth 44): At the Hoeber booth there may be seen the handsome new textbook by Paul and Juhl: *Essentials of Roentgen Interpretation.* Profusely illustrated with hundreds of large-scale reproductions, complete and authoritative in coverage, this major contribution to the literature will prove valuable to every roentgenologist. Among other new books to be seen will be Dalsace and Garcia-Calderon's *Radiologic Gynecology;* Pack and Ariel's *Treatment of Cancer;* Janzen and Shapiro's *The Normal Skull.*

Hospital Microfilming, Pearl River, N. Y. (Booth 39): Microfilming of radiographs is not new, but the new high quality results available today are worth attention. Revised lighting technics, films, and processes, along with new viewing devices will be shown at Hospital Microfilmings' exhibit. See and consider if space is at a premium in your x-ray file.

Ilford, Inc., New York, N. Y. (Booth 12): The Ilford exhibit will present a cross section of radiographic procedures illustrating the speed and latitude of Ilford Red Seal and Ilfex (no-screen) X-Ray Film, at both medium and high kvp ranges, and their use in automatic processing equipment.

Info-Dex Cancer Registry System. Medical Case History Bureau, New York, N. Y. (Booth 60A): The Info-Dex Cancer Registry System is a simple, compact, and inexpensive system which was devised in collaboration with the statistical department of the American Cancer Society and meets the requirements of the American College of Surgeons. Over 600 hospitals throughout the country are now using the "Info-Dex" Cancer Registry and several statewide central cancer registries have also set it up. Please register at Booth 60A for samples to be sent to you.

International Medical Research Corporation, New York, N. Y. (Booth 50): The new Bucky Combination Therapy Unit will be exhibited. This apparatus produces intermediary therapy, superficial therapy with a beryllium-window tube, contact and grenz ray therapy. Another feature is the stepless kv range from 5 to 140 kv depth dosage. The output is as high as 70,000 r units per minute, which makes it ideal for cavity or whole body radiation.

Keleket X-Ray Corporation, Waltham, Mass. (Booths 122–124): All radiologists are invited to visit the Keleket booth as often as possible during the meeting to view and participate in the demonstration of Keleket's newly developed units. Two image intensifiers, ceiling cranes, x-ray tables, and high-kv generators, a complete line of high performance equipment, will be exhibited.

R. S. Landauer, Jr., & Company, Matteson, Ill. (Booth 78): A descriptive display of Landauer Film Badge Services will be presented. Among the features described will be the I.B.M. system used to provide all Landauer Film Badge Service users with complete cumulative reporting. Staff personnel will be available to discuss individual personnel monitoring programs.

Lea & Febiger, Philadelphia, Penna. (Booth 15): At the Lea & Febiger booth everyone should be sure to see the following books: Fried: *Tumors of the Lungs and Mediastinum;* Pollack: *Tumor Surgery of the Head and Neck;* Epstein: *Clinical Radiology of Acute Abdominal Disorders;* Quimby, Feitelberg and Silver: *Radioactive Isotopes in Clinical Practice;* Jaffe: *Tumors and Tumorous Conditions of the Bones and Joints;* Ritvo: *Chest X-Ray Diagnosis and Bone and Joint X-Ray Diagnosis;* Ritvo and Shauffer: *Gastrointestinal X-Ray Diagnosis;* Epstein: *The Spine;* Epstein and Davidoff: *Atlas of Skull Roentgenograms;* Davidoff and Epstein: *The Abnormal Pneumoencephalogram;* Holmes and Robbins: *Roentgen Interpretation;* Rhinehart: *Roentgenographic Technique;* Pohle: *Clinical Radiation Therapy.*

Leishman X-Ray Engineering Company, Los Angeles, Calif. (Booths 95 and 96).

Liberty Protective Leathers, Inc., Gloversville, N. Y. (Booth 108).

Liebel-Flarsheim Company, Cincinnati, Ohio. (Booth 99): Liebel-Flarsheim Company, Division of Ritter Company, Inc., cordially invites inspection of their exhibit of x-ray specialty items. Of timely interest is a display featuring the new, highly efficient Rhombic Pattern Bucky Grid for use in the Super-speed Reciprocatic Potter-Bucky Diaphragm. Discriminating radiologists will find it the answer to their need of a grid with high effective ratio without critical tube positioning.

LogEtronics Inc., Alexandria, Va. (Booth 117): The LogEtronic Contact Printer, the electronic x-ray copying instrument which produces photographic copies with improved visibility of x-ray detail, and illustrative LogEgram results will be displayed.

Low X-Ray Film Corporation, New York, N. Y. (Booths 51 and 52): The Low X-Ray Film Corporation, exclusive distributors of Gevaert Blue Base X-Ray Film, cordially invites all radiologists to visit its display and to ask their representative about Gevaert High Speed X-Ray Film, Gevaert's envelope-packed x-ray film, and Gevaert Ultra Speed "Curix Rapid" X-Ray Film, which permits startling reduction in exposure while producing fine definition and contrast under regular processing conditions.

Low X-Ray Film Corporation also distributes a complete line of processing chemicals and all x-ray accessories.

Machlett Laboratories, Inc., Springdale, Conn. (Booths 111 and 112).

Donald McElroy, Chicago, Ill. (Booth 29).

Mallinckrodt Chemical Works, St. Louis, Mo. (Booth 94): Featured will be Miokon* Sodium Sterile Solution 50%, Thixokon* Sterile Solution, Pyelokon-R* and Urokon* Sodium Sterile Solution 30%, 50%, and 70%. Representatives in attendance will be glad to discuss the chemicals on display.

* Reg. U. S. Pat. Off.

Mattern X-Ray Division of Land-Air, Inc., Chicago, Ill. (Booths 73–75): An invitation is extended to visit the Mattern X-Ray booth to examine the new Mattern 500-ma control and 90°-90° table. Courteous, experienced personnel will be in attendance to answer questions. Make it a "must" to stop at the Mattern booth.

Microfilm Foto-File Company, Inc., Kansas City, Kans. (Booth 67): Microfilm Foto-File Company, Inc., are specialists in x-ray microfilming. Exclusive photographic technics now, for the first time, make possible the faithful and detailed reproduction of roentgenograms on 35-mm. microfilm. This contract service system is now being used by many radiologists throughout the country.

Micro X-Ray Recorder, Inc., Chicago, Ill. (Booth 119): Over 47 series of 2 × 2-inch medical teaching slides on various subjects, compiled from the files of leading specialists and institutions, will be featured. A Micro X-Ray Recorder and accessories for the microfilming of roentgenograms, records, charts, etc., and the PV-501 Projector-Viewer for cool projection of film strips and slides will also be shown.

Mid-West Glove Company, Inc., Chicago, Ill. (Booth 79): Security X-Ray Division will display new flexible protective gloves and aprons with protection for patients as well as for the doctor. Suggested methods and instructions for testing gloves and aprons will be available on request. Radiographs of good and poor gloves may be viewed.

National X-Ray Products Corporation, Hackensack, N. J. (Office No. 402).

North American Philips Co., Inc., New York, N. Y. (Booths 53–56).

Nuclear-Chicago Corporation, Chicago, Ill. (Booth 113): Equipment for thyroid uptake, kidney function, blood volume, cardiac output, and other radiological tests using radioisotopes will be presented.

New instruments to be featured include a surgical scintillation detector with interchangeable needle probes and a complete 3-inch scintillation detector with interchangeable collimating inserts.

Nuclear Consultants Corporation, St. Louis, Mo. (Booth 68): The Nuclear Consultants Corporation exhibit will present their complete Consulting Service, as well as their extensive line of radiopharmaceuticals. Special emphasis will be given to the display of cobalt-60 wires, needles, and tubes available from their St. Louis Laboratory and the new Glendale California Division.

Nuclear Measurements Corporation, Indianapolis, Ind. (Booth 61).

Packard Instrument Co., La Grange, Ill. (Booth 90).

Pako Corporation, Minneapolis, Minn. (Booths 41–43).

Physicians Technical Equipment Company, Milwaukee, Wisc. (Booth 104).

Picker X-Ray Corporation, White Plains, N. Y. (Booths 18–23, Office 403): Features of the Picker Exhibit will be medical nuclear instruments; Constellation 15° table with image

intensifier; film demonstration of cineradiography with 8" tube, 300 ma mobile.

Profexray, Inc., Maywood, Ill. (Booths 81 and 82): Profexray will introduce the Emperor, the 180° x-ray table designed for tomorrow. For extra operating ease in horizontal fluoroscopy, table height is instantly adjustable to the radiologist's height. Hydraulic drive produces the ultimate in smooth, quiet motion of the table.

Radiology, Detroit, Mich. (Booth 126): Radiology, the official organ of the Radiological Society of North America, is happy to announce the completion of its Fourth Cumulative Index, covering the years 1953 through 1957. Copies of the Index will be exhibited and representatives from the Editorial Office will be glad to answer any questions regarding it, as well as supplying information to contributors, would-be contributors, and readers of Radiology.

Radium Chemical Company, Inc., New York, N. Y. (Booth 14): The Radium Chemical Company will feature their modern cervical-uterine radium applicators. These latest instruments and accessories for the handling and application of radium and radon will be demonstrated by representatives in attendance. Special protective and handling equipment designed for use in hospital and office will also be displayed.

Schick X-Ray Company, Inc., Chicago, Ill. (Booth 107): Elema-Schönander A.B. of Stockholm, Sweden, manufactures special equipment for angiocardiography, catheterization, skull radiography, etc. For all these units the exclusive United States distributor is Schick X-Ray Company, Inc.

Frank Scholz Corporation, Boston, Mass. (Booth 93).

Siemens New York, Inc., X-Ray Division, New York, N. Y. (Booths 84–86): The advantage of reducing the patient dose and the exposure mas—the latter by 50%—when using three-phase generators, is being recognized with growing rapidity. The Tridoros 5 to be displayed by Siemens represents such a unit—powerful, yet moderate in price. A highly flexible single column therapy tube stand and treatment table will also be shown.

E. R. Squibb & Sons, New York, N. Y. (Booth 37): E. R. Squibb & Sons has long been a leader in development of new therapeutic agents for prevention and treatment of disease. The results of diligent research are available to the medical profession in new products or improvements in products already marketed. At Booth 37 information on these advances will be offered for consideration.

Standard X-Ray Company, Chicago, Ill. (Booths 8–11): The Standard X-Ray Company will exhibit the latest developments in diagnostic x-ray apparatus, including a table designed to permit angulation from 90° Trendelenburg to 90° vertical. Attendants will be most pleased to demonstrate the features of this new apparatus, including the unique mounting and parking arrangement of the spot-film device.

A 200-ma full-wave rectified mobile x-ray unit will also be exhibited. This mobile unit incorporates a newly developed tube stand which provides an extension of up to 48" of the tube from the supporting vertical column. This permits extending the x-ray tube to any position desired over the hospital bed, with minimum effort and disturbance to the patient.

Tracerlab Inc., Waltham, Mass. (Booths 120 and 121): The Tracerlab exhibit will feature an entirely new line of nucleonic instrumentation for the radioisotope laboratory or clinic. Among these will be a low-cost medical spectrometer, a transistorized scintillation detector, an automatic sample change for well-type detectors, Tracerlab's automatic data printing devices, and Tracerlab's unique Twin-film Service.

U. S. Radium Corporation, Morristown, N. J. (Booth 72).

The Victoreen Instrument Company, Cleveland, Ohio. (Booths 62 and 63): The Victoreen Instrument Company exhibit will feature the new Direct Reading Minometer II, providing an optional sensitivity increase of 10 to 1 on a standard dosimeter; 200 mr dosimeters can now be read more accurately on ranges of 0–200 mr and 0–20 mr full scale. Other x-ray dose measurement and new counting equipment will also be shown.

Videx Sales, Inc. (Affiliate of Howdon Videx Products Corporation), Mount Vernon, N. Y. (Booth 64): Mr. Leonard F. Peyser will be on hand to demonstrate and discuss Videx radiographic cones and collimators. The advanced new Fairfield 150, with a unique filtration dial, will be shown, together with an improved Model C-2 rectangular diaphragming cone of 125-kvp rating. Full field visualizers will be featured.

Westinghouse Electric Corporation, Pittsburgh, Penna. (Booths 1–6).

The Williams & Wilkins Company, Baltimore, Md. (Booth 87): *Diagnostic Roentgenology*, the famous 3-volume loose-leaf set edited by Ross Golden, is featured this year and includes the 1959 revisions. The publisher has made special arrangements to include at no extra charge with each set ordered at the booth four revised chapters to be published in 1960. Many other recent radiological books will be shown.

Winthrop Laboratories, New York, N. Y. (Booth 28): Winthrop Laboratories will feature Lavema Enema Powder, a new colonic actuator, useful as a radiologic adjuvant. It may be used as (*a*) a *cleansing* enema before flat plates, excretion urography, cholecystography, proctoscopy, and sigmoidoscopy, and (*b*) as a radiopaque enema adjuvant with barium enema suspension for routine colon studies and double air-contrast examinations.

Wolf X-Ray Products, Inc., Brooklyn, N. Y. (Booths 46–49).

X-Ray Engineers, Inc., Nashville, Tenn. (Booth 77): X-Ray Engineers will display a novel means of cooling or heating fluids, solutions or solids. By this means x-ray or photo chemicals, milk or x-ray tube anodes, transformers, and insulating oils are readily chilled or warmed. Desiccation of water-bearing mixtures by moisture condensation is greatly simplified by this device. Its applications are unlimited.

Year Book Publishers, Inc., Chicago, Ill. (Booth 118): Year Book Publishers will feature several interesting and important new publications: notably the new second edition of *Kjellberg's Diagnosis of Congenital Heart Disease; Lusted and Keats' Atlas of Roentgenographic Measurement; Singleton's X-Ray Diagnosis of the Alimentary Tract in Infants and Children.* Also on display will be the third edition of Caffey's *Pediatric X-Ray Diagnosis,* plus other radiologic texts and reference books.

RADIOLOGICAL SOCIETIES: SECRETARIES AND MEETING DATES

Editor's Note: Secretaries of state and local radiological societies are requested to co-operate in keeping this section up-to-date by notifying the editor promptly of changes in officers and meeting dates.

RADIOLOGICAL SOCIETY OF NORTH AMERICA. *Secretary-Treasurer*, Donald S. Childs, M.D., 713 E. Genesee St., Syracuse 2, N. Y.

AMERICAN RADIUM SOCIETY. *Secretary*, Robert L. Brown, M.D., Robert Winship Clinic, Emory University, Atlanta 22, Ga.

AMERICAN ROENTGEN RAY SOCIETY. *Secretary*, C. Allen Good, M.D., Rochester, Minn.

AMERICAN COLLEGE OF RADIOLOGY. *Exec. Secretary*, William C. Stronach, 20 N. Wacker Dr., Chicago 6.

AMERICAN CLUB OF THERAPEUTIC RADIOLOGISTS. *Secretary*, Juan A. del Regato, M.D., 2200 North Cascade Ave., Colorado Springs, Colo.

ASSOCIATION OF UNIVERSITY RADIOLOGISTS. *Secretary-Treasurer*, Paul A. Riemenschneider, M.D., 736 Irving Ave., Syracuse 10, N. Y.

SECTION ON RADIOLOGY, A. M. A. *Secretary*, T. Leucutia, M.D., 10 Peterboro, Detroit 1, Mich.

SOCIETY OF NUCLEAR MEDICINE. *Secretary*, Robert W. Lackey, M.D., 452 Metropolitan Bldg., Denver 2, Colo.

Alabama

ALABAMA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Garland Wood, Jr., M.D., Medical College of Alabama, Birmingham 3.

Arizona

ARIZONA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, R. Lee Foster, M.D., 1313 N. Second St., Phoenix. Annual meeting with State Medical Association; interim meeting in December.

Arkansas

ARKANSAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. B. Scruggs, M.D., 1700 W. 13th St., Little Rock. Meets quarterly.

California

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY. *Secretary*, William H. Graham, M.D., 630 E. Santa Clara St., San Jose.

EAST BAY ROENTGEN SOCIETY. *Secretary*, Dan Tucker, M.D., 434 30th St., Oakland 9. Meets monthly, first Thursday, at Peralta Hospital.

LOS ANGELES RADIOLOGICAL SOCIETY. *Secretary*, Denis C. Adler, M.D., 2010 Wilshire Blvd., Los Angeles 57. Meets second Wednesday, September, November, March, April, and June, Los Angeles County Medical Association Building.

NORTHERN CALIFORNIA RADIOLOGICAL SOCIETY. *Secretary*, Rob H. Kirkpatrick, M.D., 1219 28th St., Sacramento 16. Meets last Monday of each month, September through June.

PACIFIC ROENTGEN SOCIETY. *Secretary*, L. Henry Garland, M.D., 450 Sutter St., San Francisco 8. Meets annually at time of California State Medical Association convention.

RADIOLOGICAL SOCIETY OF SOUTHERN CALIFORNIA. *Secretary*, Joseph F. Linsman, M.D., 436 N. Roxbury Dr., Beverly Hills.

REDWOOD EMPIRE RADIOLOGICAL SOCIETY. *Secretary*, Lee E. Titus, M.D., 164 W. Napa Street, Sonoma, Calif. Meets second Monday every other month.

SAN DIEGO RADIOLOGICAL SOCIETY. *Secretary*, Stanley A. Moore, M.D., 2466 First Ave., San Diego 1. Meets first Wednesday of each month.

SAN FRANCISCO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, M. A. Sisson, M.D., 450 Sutter St., San Francisco 8. Meets quarterly, at Grison's Steak House.

SOUTH BAY RADIOLOGICAL SOCIETY. *Secretary*, Stanford B. Rossiter, M.D., 1111 University Dr., Menlo Park. Meets second Wednesday every month.

X-RAY STUDY CLUB OF SAN FRANCISCO. *Secretary*, John H. Heald, M.D., 450 Sutter St., San Francisco 8. Meets third Thursday at 7:30 P.M., Children's Hospital, September through June.

Colorado

COLORADO RADIOLOGICAL SOCIETY. *Secretary*, Lorenz R. Wurtzebach, M.D., 601 E. Nineteenth Ave., Denver 5. Meets monthly, third Friday, at Denver Athletic Club.

Connecticut

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary-Treasurer*, Ralph J. Littwin, M.D., Bristol Hospital, Bristol. Meets bimonthly, second Wednesday.

District of Columbia

RADIOLOGICAL SECTION, DISTRICT OF COLUMBIA MEDICAL SOCIETY. *Secretary-Treasurer*, William E. Sheely, M.D., 1746 K St., N.W., Washington 6. Meets third Wednesday, January, March, May, and October, 8:00 P.M., in Medical Society Library.

Florida

FLORIDA RADIOLOGICAL SOCIETY. *Secretary*, John P. Ferrell, M. D., 166 4th Ave., St. Petersburg.

FLORIDA WEST COAST RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Joseph C. Rush, M.D., 1501 Jungle, St. Petersburg. Meets third week of October, January, April, and July.

GREATER MIAMI RADIOLOGICAL SOCIETY, *Secretary-Treasurer*, George P. Daurelle, M.D., Jackson Memorial Hospital, Miami 36. Meets monthly, third Wednesday, 8:00 P.M., at Jackson Memorial Hospital.

NORTH FLORIDA RADIOLOGICAL SOCIETY. *Secretary*, Paul A. Mori, M.D., 800 Miami Road, Jacksonville 7. Meets quarterly, March, June, September, and December.

Georgia

ATLANTA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Luther Clements, Jr., M.D., 35 Linden Ave., N.E., Atlanta 8. Meets second Friday, September to May.

GEORGIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, George W. Brown, M.D., 317 S. 8th St., Griffin, Ga. Meets in November and at the annual meeting of the State Medical Association.

RICHMOND COUNTY RADIOLOGICAL SOCIETY. *Secretary*, Wm. F. Hamilton, Jr., M.D., University Hospital, Augusta. Meets first Thursday of each month.

Hawaii

RADIOLOGICAL SOCIETY OF HAWAII. *Secretary-Treasurer*, Louis L. Buzaid, M.D., The Queen's Hospital, Box 861, Honolulu. Meets third Monday of each month.

Idaho

IDAHO STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Charles R. McWilliams, M.D., Twin Falls.

Illinois

CHICAGO ROENTGEN SOCIETY. *Secretary-Treasurer*, George B. Cahill, M.D., 802 Burns Ave., Flossmoor, Ill. Meets at the Sheraton Hotel, second Thursday of October, November, January, February, March, and April at 8:00 P.M.

ILLINOIS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, George A. Miller, M.D., Carle Hospital Clinic, Urbana. Spring and Fall meetings.

ILLINOIS STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary*, William Meszaros, M.D., 1825 W. Harrison St., Chicago.

Indiana

INDIANA ROENTGEN SOCIETY. *Secretary-Treasurer*, David E. Wheeler, M.D., 1500 North Ritter, Indianapolis. Meets twice a year, first Sunday in May and during fall meeting of State Medical Association.

TRI-STATE RADIOLOGICAL SOCIETY (Southern Indiana, Northwestern Kentucky, Southeastern Illinois). *Secretary-Treasurer*, James R. Mathews, M.D., 118 S. E. First St., Evansville, Ind. Meets October, January, March, and May.

Iowa

IOWA RADIOLOGICAL SOCIETY. *Secretary*, James T. McMillan, M.D., 1104 Bankers Trust Bldg., Des Moines. Meets during annual session of State Medical Society, and in the Fall.

Kansas

KANSAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Lewis G. Allen, M.D., 807 Huron Bldg., Kansas City, Kans. Meets in the Spring with the State Medical Society and in the Winter on call.

Kentucky

KENTUCKY RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Robert H. Akers, M.D., VA Hospital, Louisville 2. Meets monthly, second Friday, at Seelbach Hotel, Louisville.

Louisiana

ORLEANS PARISH RADIOLOGICAL SOCIETY. *Secretary*, Joseph V. Schlosser, M.D., Charity Hospital of Louisiana, New Orleans 13. Meets second Tuesday of each month.

RADIOLOGICAL SOCIETY OF LOUISIANA. *Secretary-Treasurer*, Seymour Ochsner, M.D., Ochsner Clinic, New Orleans 15.

SHREVEPORT RADIOLOGICAL CLUB. *Secretary*, W. R. Harwell, M.D., 608 Travis St. Meets monthly, September to May, third Wednesday.

Maine

MAINE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Edward C. Porter, M.D., Eastern Maine General Hospital, Bangor. Meets in June, October, December, and April.

Maryland

MARYLAND RADIOLOGICAL SOCIETY. *Secretary*, Albert B. Shackman, M.D., 705 Medical Arts Bldg., Baltimore 1.

Michigan

DETROIT X-RAY AND RADIUM SOCIETY. *Secretary-Treasurer*, Joseph O. Reed, Jr., M.D., 3825 Brush, Detroit 1. Meets first Thursday, October to May, Wayne County Medical Society rooms.

UPPER PENINSULA RADIOLOGICAL SOCIETY. *Secretary*, Arthur Gonty, M.D., Menominee. Meets quarterly.

Minnesota

MINNESOTA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Donald H. Peterson, M.D., 25 W. Fourth St., St. Paul 2. Meets Fall, Winter, and Spring.

Mississippi

MISSISSIPPI RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Bernard T. Hickman, M.D., University of Mississippi Medical Center, Jackson. Meets monthly, on third Thursday, 6:00 P.M., at Hotel Edwards, Jackson.

Missouri

GREATER ST. LOUIS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Harvey A. Humphrey, M.D., 510 S. Kingshighway, St. Louis 10. Meets on fourth Wednesday, October to May.

RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY. *Secretary-Treasurer*, Samuel B. Chapman, Jr., M.D., 830 Argyle Bldg., Kansas City, Mo. Meets last Friday of each month.

Montana

MONTANA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Arthur T. Austin, M.D., 104 Doctors Bldg., Billings. Meets annually.

Nebraska

NEBRASKA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Warren Quinton Bradley, M.D., 206 S. 13th St., Lincoln 8. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

New England

CONNECTICUT VALLEY RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Paul J. Kingston, M.D., 114 Woodland St., Hartford, Conn. Meets second Friday of October and April.

NEW ENGLAND ROENTGEN RAY SOCIETY. *Secretary*, John E. Gary, M.D., 1180 Beacon St., Brookline 46, Mass. Meets third Friday, October through May, Longwood Towers, Brookline, Mass.

New Hampshire

NEW HAMPSHIRE ROENTGEN RAY SOCIETY. *Secretary-Treasurer*, Paul Y. Hasserjian, M.D., 1470 Elm St., Manchester. Meets three times a year.

New Jersey

RADIOLOGICAL SOCIETY OF NEW JERSEY. *Secretary*, Austin J. Tidaback, M.D., 912 Prospect Ave., Plainfield. Annual meeting in Spring, Atlantic City; Fall meeting October or November, Newark.

New York

BROOKLYN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, George A. Manfredonia, M.D., One Hanson Place, Brooklyn. Meets first Thursday of each month.

BUFFALO RADIOLOGICAL SOCIETY. *Secretary*, Alfred H. Dobrak, M.D., Sisters of Charity Hospital, Buffalo 14. Meets second Monday, October to May.

CENTRAL NEW YORK RADIOLOGICAL SOCIETY. *Secretary*, Joseph A. Head, M.D., University Hospital, 150 Marshall St., Syracuse. Meets first Monday, October through May.

KINGS COUNTY RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, C. P. Naidorf, M.D., 411 Parkside Ave., Brooklyn 26. Meets fourth Thursday, October to April (except December), at 9:00 P.M., Kings County Medical Bldg.

NASSAU RADIOLOGICAL SOCIETY. *Secretary*, Jerome Zwanger, M.D., 126 Hicksville Road, Massapequa. Meets second Tuesday, February, April, June, October, and December.

NEW YORK ROENTGEN SOCIETY. *Secretary*, William B. Seaman, M.D., 622 W. 168th St., New York 32, N. Y.

NORTHEASTERN NEW YORK RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Irving Van Woert, Jr., M.D., Albany Hospital, Albany. Meets in the capital area second Wednesday, October, November, March, and April; annual meeting, May or June.

RADIOLOGICAL SOCIETY OF STATE OF NEW YORK. *Secretary-Treasurer*, Mario C. Gian, M.D., 610 Niagara St., Buffalo 1. Meets annually with the State Medical Society.

ROCHESTER ROENTGEN-RAY SOCIETY. *Secretary-Treasurer*, Theodore F. VanZandt, M.D., 501 W. Main St., Rochester 8. Meets last Monday of each month, September through May.

WESTCHESTER RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, James C. Monteith, M.D., 170 Maple Ave., White Plains. Meets third Tuesday of January and October and as announced.

North Carolina

RADIOLOGICAL SOCIETY OF NORTH CAROLINA. *Secretary-Treasurer*, Charles Bream, M.D., North Carolina Memorial Hospital, Chapel Hill, N. C. Meets in Spring and Fall of each year.

North Dakota

NORTH DAKOTA RADIOLOGICAL SOCIETY. *Secretary*, Marianne Wallis, M.D., Minot. Meets in the Spring with State Medical Association; in Fall or Winter on call.

Ohio

OHIO STATE RADIOLOGICAL SOCIETY. *Secretary*, Paul D. Meyer, M.D., 125 S. Grant Ave., Columbus. Next annual meeting, Toledo, May 20–22, 1960.

CENTRAL OHIO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, William B. Schwartz, M.D., 1500 W. Third Ave., Columbus 12. Meets second Thursday, October, November, January, March, and May, 6:30 P.M., Fort Hayes Hotel, Columbus.

CLEVELAND RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Frederick A. Rose, M.D., 2065 Adelbert Road, Cleveland 6. Meets at 7:00 P.M., fourth Monday, October, November, January, February, March, and April, at Tudor Arms Hotel.

GREATER CINCINNATI RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John E. Singer, M.D., 19 Garfield Pl., Cincinnati 2. Meets first Monday, September through May, at Cincinnati General Hospital.

MIAMI VALLEY RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, G. F. Johnson, M.D., 1030 Reibold Bldg., Dayton 2, Ohio. Meets monthly, second Thursday, Miami Valley Hospital, Dayton.

Oklahoma

OKLAHOMA STATE RADIOLOGICAL SOCIETY. *Secretary*, J. Murphree, M.D., 617 E. Brookfield, Ponca City.

Oregon

OREGON RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Barbara J. Radmore, M.D., 1162 Willamette St., Eugene. Meets monthly, second Wednesday, October to June, at 8:00 P.M., University Club, Portland.

Pacific Northwest

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Arch Colbrunn, Jr., M.D., 164 W. Tanager St., Roseburg, Ore. Next annual meeting in Vancouver, B. C., in May 1960.

Pennsylvania

PENNSYLVANIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Walter P. Bitner, M.D., 234 State St., Harrisburg. Next annual meeting, May 14–15, 1960, Pocono Manor.

PHILADELPHIA ROENTGEN RAY SOCIETY. *Secretary*, Robert B. Funch, M.D., Germantown Hospital, Philadelphia 44. Meets first Thursday of each month at 5:00 P.M., from October to May, in Thompson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY. *Secretary*, Charles N. Chasler, M.D., Elizabeth Steel Magee Hospital, Pittsburgh 13. Meets monthly, second Wednesday, October through June, Park Schenley Restaurant.

Rocky Mountain States

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John H. Freed, M.D., 4200 E. Ninth Ave., Denver 20, Colo. Next annual meeting, Aug. 11–13, 1960, Denver Hilton Hotel, Denver.

South Carolina

SOUTH CAROLINA RADIOLOGICAL SOCIETY. *Secretary*, Wayne Reeser, M.D., 1600 Ninth Ave., Conway. Meets with State Medical Association in May.

South Dakota

RADIOLOGICAL SOCIETY OF SOUTH DAKOTA. *Secretary-Treasurer*, Donald J. Peik, M.D., 303 S. Minnesota Ave., Sioux Falls. Meets during annual meeting of State Medical Society.

The Southeast

Southern Radiological Conference. *Secretary-Treasurer*, Marshall Eskridge, M.D., 1252 Springhill Ave., Mobile, Ala.

The Southwest

SOUTHWESTERN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Gordon L. Black, M.D., 1501 Arizona Bldg., El Paso, Texas.

Tennessee

EAST TENNESSEE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Charles W. Reavis, M.D., Baroness Erlanger Hospital, Chattanooga. Meets in September and January, and prior to State Medical Association meeting.

MEMPHIS ROENTGEN SOCIETY. *Secretary-Treasurer*, Hollis H. Halford, M.D., Kennedy VA Hospital, Memphis 15. Meets monthly first Monday, John Gaston Hospital.

TENNESSEE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, James J. Range, M.D., P. O. Box 324, Johnson City. Meets annually with State Medical Association in April.

Texas

CENTRAL TEXAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Glenn Addison Stokdyk, M.D., VA Center, Temple. Meets monthly, fourth Monday, at Kosel's Cafe, Temple.

DALLAS-FORT WORTH RADIOLOGICAL CLUB. *Secretary*, Albert H. Keene, M.D., 3707 Gaston Ave., Dallas. Meets monthly, third Monday, 6:30 P.M., at the Greater Fort Worth International Airport.

HOUSTON RADIOLOGICAL SOCIETY. *Secretary*, Edward Singleton, M.D., 6621 Fannin St., Houston 25. Meets last Monday of each month at the Doctors' Club.

SAN ANTONIO-MILITARY RADIOLOGICAL SOCIETY. *Secretary*, Hugo F. Elmendorf, Jr., M.D., 730 Medical Arts Bldg., San Antonio 5, Texas. Meets at Fort Sam Houston Officers' Club, third Wednesday of each month, 6:30 P.M.

TEXAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, R. P. O'Bannon, M.D., 1216 Pennsylvania Ave., Fort Worth 4. Next meeting in Houston, Jan. 22–23, 1960.

Utah

UTAH STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Wm. R. Christensen, M.D., 2033 S. State St., Salt Lake City 5. Meets third Wednesday, January, March, May, September, November.

Virginia

VIRGINIA RADIOLOGICAL SOCIETY. *Secretary*, Frank A. Kearney, 2nd, M.D., 110 S. Curry St., Phoebus.

Washington

WASHINGTON STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Wayne A. Chesledon, M.D., 306 Stimson Bldg., Seattle 1. Meets fourth Monday, September through April, at College Club, Seattle.

West Virginia

WEST VIRGINIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Karl J. Myers, M.D., Myers Clinic-Broaddus Hospital, Philippi. Meets with State Medical Society, and as arranged by Program Committee.

Wisconsin

MILWAUKEE ROENTGEN RAY SOCIETY. *Secretary-Treasurer*, Joseph F. Wepfer, M.D., 5000 W. Chambers St., Milwaukee 10. Meets fourth Monday, October through May, at the University Club.

SECTION ON RADIOLOGY, STATE MEDICAL SOCIETY OF WISCONSIN. *Secretary*, Abraham Melamed, M.D., 425 E. Wisconsin Ave., Milwaukee 2. Meets in October with State Medical Society.

WISCONSIN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Howard G. Bayley, M.D., 124 Winn Terrace, Beaver Dam.

Puerto Rico

ASOCIACIÓN PUERTORRIQUEÑA DE RADIOLOGÍA. *Secretary-Treasurer*, Dr. R. B. Díaz Bonnet, Suite 504, Professional Bldg., Santurce, P.R.

CANADA

CANADIAN ASSOCIATION OF RADIOLOGISTS. *Honorary Secretary-Treasurer*, Robert G. Fraser, M.D.; *Associate Honorary Secretary-Treasurer*, Jean-Louis Leger, M.D. *Central Office*, 1555 Summerhill Ave., Montreal 25, Quebec. Meets in January and June.

LA SOCIÉTÉ CANADIENNE-FRANÇAISE D'ELECTRO-RADIOLOGIE MÉDICALES. *General Secretary*, Louis Ivan Vallée, M.D., Hôpital Saint-Luc, 1058 rue St-Denis, Montreal 18. Meets third Saturday of each month.

L'ASSOCIATION DES RADIOLOGISTS DE LA PROVINCE DE QUEBEC. ASSOCIATION OF RADIOLOGISTS OF THE PROVINCE OF QUEBEC. *Secretary*, O. Raymond, M.D., 5400 Blvd. Gouin W., Montreal 9. Meets four times a year.

MONTREAL RADIOLOGICAL STUDY CLUB. *Secretary*, Douglas W. MacEwan, M.D., 2300 Tupper St., Montreal 25, Quebec. Meets first Tuesday evening, October to April.

TORONTO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, L. R. Harnick, M.D., X-Ray Department, Toronto Western Hospital, 399 Bathurst St. Meets second Monday evening, September to May.

CUBA

SOCIEDAD CUBANA DE RADIOLOGÍA Y FISIOTERAPIA. *Secretary*, Dr. Miguel A. García Plasencia, Hospital Curie, 29 y F, Vedado, Havana. Meets monthly.

MEXICO

SOCIEDAD MEXICANA DE RADIOLOGÍA. *Headquarters*, Calle de Coahuila, Núm. 35, Mexico 7, D. F. *Secretary General*, Dr. Jorge Ceballos Labat. Meets first Monday of each month.

PANAMA

SOCIEDAD RADIOLÓGICA PANAMEÑA. *Secretary-Editor*, Luis Arrieta Sánchez, M.D., Apartado No. 86, Panama, R. de P.

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Local Bulging of the Skull and External Hydrocephalus Due to Cerebral Agenesis. R. G. Robinson. Brit. J. Radiol. **31:** 691–700, December 1958. (Dunedin Hospital, Dunedin, New Zealand)

The author reports 5 new cases, and refers to 2 which he had previously reported (J. Neurosurg. **12:** 345, 1955), of localized bulging of the temporal profile of the skull related to external hydrocephalus over an area of agenesis of the temporal lobe of the brain. Local bulging of the skull has also been described as an uncommon finding associated with cerebral neoplasm, cyst, or chronic subdural hematoma.

On the basis of his own cases and a number from the literature, the author has found it possible to define an entity of local bulging of the temporal region with external hydrocephalus due to cerebral agenesis. There are usually thinning and outward bulging of the temporal squama with forward and upward protrusion of the lesser and greater wings of the sphenoid. The syndrome of associated external hydrocephalus and cerebral agenesis occurs predominantly in males (4 to 1) under twenty-one years of age. The left side is more commonly involved (3 to 1). Symptoms are negligible and epilepsy is unusual. The consistent clinical finding is a firm painless temporal swelling, which may spread to include the parietal area and forehead. Less frequently there is a mild degree of exophthalmos. Papilledema and hemiplegic signs are an indication that an intracranial hematoma has supervened.

Air studies of the ventricular system show slight displacement of the septum pellucidum away from the bulge, but this is seldom more than a few millimeters. The area of external hydrocephalus does not fill on pneumoencephalography.

Carotid arteriograms offer differential information. On the anteroposterior projection, the middle cerebral artery arises from the internal carotid in a vertical direction. There may be a gap between the cortical vessels and the skull, the line of the cortex being convex rather than flattened or concave as in subdural hematoma. There is minimal or no displacement of the anterior cerebral artery to the opposite side. In the lateral arteriograms, the middle cerebral artery does not show the degree of upsweeping that is observed with temporal lobe tumors. The area of the temporal lobe is also avascular.

Pathologically, there is absence of the temporal pole and some deficiency of the frontal lobe. The insula is visible as the opercula are absent. The condition is liable to the complication of blood clot formation. This usually occurs in the external hydrocephalus. In other instances, the hematoma is separate but adjacent —a true subdural hematoma in its classical site over the convexity of the brain. Such a hematoma may even be on the opposite side of the brain.

This condition is probably a primary developmental error of brain areas which differentiate late in fetal life. The overlying cyst is usually closed and may contain up to 500 c.c. of fluid. It is thought to be part of the subarachnoid cavity, however.

The author doubts the existence of the entity called relapsing juvenile subdural hematoma as described by Davidoff and Dyke as a cause of the similar skull changes because of the location of the hematomas on the superolateral aspect of the brain, far from the deformed middle fossa. He believes these are actually cases of cerebral agenesis with a superimposed hematoma.

Twelve roentgenograms; 2 photographs.

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Angiographic Experiences in Basilar Skull Projection. L. Ghirardi, L. Garello, and M. Lertora. Ann. di radiol. diag. **31:** 102–118, 1958. (In Italian) (Università di Genova, Genoa, Italy)

The authors have added the submento-vertical projection of the skull in cerebral angiography to the conventional frontal and lateral views in order to obtain three-dimensional information about the position of the vessels. Four normal angiograms are reproduced, together with angiograms in 14 abnormal cases in which the basilar view proved to be of value. The addition of the third view in their opinion will reduce errors in the exact localization of a lesion causing displacement of intracranial vessels.

Forty-seven roentgenograms.

ALEXANDER R. MARGULIS, M.D.
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Changes in the Optic Canal in Tumors of the Optochiasmatic Region. Nicolas Blatt and Mircea Athanasiu. J. de radiol. **39:** 815–831, December 1958. (In French) (Bucharest, Romania)

In tumors of the optochiasmatic region, the roentgen examination is a most important factor in differential diagnosis. In certain cases, in spite of ophthalmoscopic and visual-field studies, clinical examination, and routine roentgenography, the differentiation between pituitary adenoma and meningioma remains uncertain. If the anterior clinoid processes are eroded and unequal, a meningioma with a suprasellar point of departure is indicated. In cases of pituitary adenoma, however, roentgenography shows, in the majority of cases, an intact optic canal. Differentiation is important because pituitary adenomas may be treated by roentgen rays alone, whereas surgery is required for definitive therapy of meningioma.

Clinical and roentgen observations on 11 cases are reported.

There are thirty-four excellent roentgenographic reproductions with several diagrammatic sketches and 1 photograph.

CHARLES M. NICE, JR., M.D., Ph.D.
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Skull Changes in Neurofibromatosis of von Recklinghausen. K. Meinardus. Radiol. clin. **27:** 357–364, November 1958. (In German) (Universitäts-Röntgeninstitut Basel, Switzerland)

The author discusses the roentgenologic changes in the skull in von Recklinghausen's disease. There may be marked asymmetry in the facial skeleton or the calvarium; asymmetry and defects in the orbit and mandible; reduction in size of a mastoid or an antrum; osteoporosis or sclerosis, or erosions in the internal table; sclerosis in the zygomatic bone and temporal bone, as well as in the anterior and middle cranial fossae; defects in the lesser or greater wing of the sphenoid, or in the zygomatic arch; widening of the optic foramen, of the foramina lacerum, rotundum, ovale, spinosum, and of the porus acusticus; asymmetry of the foramen mag-

num; sellar changes with no corresponding modification of the pituitary.

These findings are often associated with tumors of the face or with neurofibromatous formations of the nerves, and can lead to neurological and ophthalmological disturbances. At other times no direct connection between the skeletal changes and neurofibromata can be determined.

While the origin of the bony changes in neurofibromatosis is not completely agreed upon, one must differentiate the secondary changes which are directly related to the tumors, from the primary, with no direct relation, which are probably developmental. Examples of the latter are widening of the optic foramen or foramen ovale, with no neurologic symptoms, and changes in the size of the sella without demonstrable endocrine disturbances or signs of increased intracranial pressure.

A case in a forty-year-old patient is reported.

Four roentgenograms.

CHRISTIAN V. CIMMINO, M.D.
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The Practical Value of the Internal Cerebral Vein in the Anteroposterior Phlebogram. Frederick Murtagh and Herbert M. Stauffer. Am. J. Roentgenol. **80:** 978–981, December 1958. (Temple University, Philadelphia, Penna.)

The authors' "experience with phlebograms in more than 1,000 carotid angiographies" has indicated that the most valuable finding is lateral displacement of the internal cerebral vein. The internal cerebral vein runs in the roof of the third ventricle, 1.0 mm. lateral to the midline. It lies well below the edge of the falx cerebri and anterior to the tentorium cerebelli. It is therefore more easily displaced than the pineal gland, which is somewhat protected by these fixed structures. A marked lateral shift of the vein may be seen in the anteroposterior projection with a normal pattern in the lateral projection.

Discrepancy between the lateral displacement of the anterior cerebral artery and that of the internal cerebral vein may be of aid in localization of tumors. For example, expanding lesions in the frontal hemispheres will produce maximal displacement of the anterior cerebral artery with little or no shift of the vein, while more posterior lesions will shift the vein to a greater degree. Maximal shift of the vein occurs with temporal lobe or midhemisphere lesions. Lesions in the parietal-occipital area will shift the vein, with no displacement of the artery. Equal displacement of vein and artery may be caused by a lesion between the two vessels or by diffuse involvement of the hemisphere by edema, glioma, or multiple metastatic lesions. When the anterior cerebral artery does not fill, lateral displacement of the internal cerebral vein may be the only sign of an intracranial mass.

Ten roentgenograms.

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The Roentgenologic Characteristics of Chondroma of the Larynx. Brit B. Gay, Jr., Sam A. Wilkins, Jr., and Edward P. Engels. Am. J. Roentgenol. **80:** 987–996, December 1958. (Emory University, Atlanta 22, Ga.)

One hundred eighteen cases of laryngeal chondroma were found in a review of the literature, only one of which appeared in an English-language roentgenologic journal (Ryan, M.D., and Zizmor, J.: Am. J. Roentgenol. **62:** 715, 1949). Three cases are added by the authors and the roentgenologic signs in these and 26 of the reviewed cases are analyzed.

The tumors are hard, rounded or lobulated, and submucosal. They are composed of normal cartilage and vary from 1 to 8 cm. in diameter. Malignant change may occur (13 out of 118), but this is difficult to determine histologically. The most common site of origin is the endolaryngeal surface of the posterior plate of the cricoid cartilage. Next in frequency is the thyroid cartilage. Multiple cartilaginous involvement occurred in 25 per cent of the cases. Epiglottic and arytenoid involvement is rare. The tumors are much more frequent in males and are essentially limited to adults. The age range is from fifteen years to eighty-one years. Hemoptysis is uncommon. The clinical course is the result of local changes. Pain is not a predominant symptom. The mucous membrane is usually intact.

Because of the site of origin, the most frequent location recognized roentgenologically is the posterior aspect of the subglottic space. A soft-tissue density can be seen impinging on the laryngeal airway below the level of the vocal cords. Calcification is common (about three-fourths of the 26 cases) and is usually demonstrable as multiple stippled density. Movement of the vocal cords may be comprised, but fixation is not as common as in carcinoma. Larger tumors may displace the esophagus. In some cricoid chondromas, the tumor may project from one side of the subglottic space and not in the midline.

When originating from the thyroid cartilage, the tumor is eccentric. Here the pyriform sinuses are obliterated. The aryepiglottic fold may bulge into the laryngeal vestibule. The cords may be displaced and the ventricle obliterated. Expansion may be external only, without the above appearances. Chondroma of the vocal cord is rare and without calcification; it is indistinguishable from other masses.

Inflammatory lesions, amyloidosis, tuberculosis, fibromas, cysts, neurogenic tumors, and lipomas may present as submucosal masses and therefore simulate chondroma.

Seven roentgenograms, 1 photograph; 5 diagrams.

VAHE MEGHROUNI, M.D.
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Calcification in Papillary Carcinoma of the Thyroid. S. Holtz and W. E. Powers. Am. J. Roentgenol. **80:** 997–1000, December 1958. (100 N. Euclid, St. Louis 10, Mo.)

Psammoma bodies have been found histologically in papillary carcinoma of the thyroid, and their roentgen recognition is diagnostic of that condition. When a thyroid tumor is suspected, attempts should be made to demonstrate and correctly interpret these calcifications on a routine chest film or on special neck films, including anteroposterior, lateral, and oblique views taken with soft-tissue technic.

The authors' material consisted of 53 proved cases of papillary carcinomas of the thyroid seen over a period of ten years. Twenty-eight of the patients had chest films and some had special films of the neck. Histologic examination of the surgical specimens revealed 12 cases with psammoma bodies within the papillary carcinoma. Roentgenograms of 3 of the 12 patients showed evidence of calcifications in the thyroid which the authors believed to be typical for psammoma bodies.

A case is reported in which the preoperative diagnosis of papillary carcinoma was made. A chest film showed displacement of the trachea by a soft-tissue mass containing soft flocculent calcifications.

Two roentgenograms; 1 microphotograph.

MAX EICHWALD, M.D.
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Pain in the Neck: The Radiologist's Contribution. Frank R. Kinsey. Pennsylvania M. J. **61:** 1628–1631, December 1958. (Lewistown Hospital, Lewistown, Penna.)

Cervical pain caused by peripheral nerve root irritation is characterized by muscle spasm, localized areas of tenderness, hyperesthesia, paresthesia, and, to a lesser degree, hypesthesia, motor weakness, and abnormal reflexes.

Before therapy is instituted in any patient with pain in the neck and/or shoulders, roentgen examination of the cervical spine is indispensable—for medicolegal if not for diagnostic reasons.

In cases where there is no history of trauma, simple survey films in anteroposterior and lateral projections usually suffice. The chief purpose here is to be certain that there is no contraindication to treatment. If the patient has suffered a recent injury, a complete examination is essential. This will include at least the seven routine projections for study of all portions of the cervical spine.

Radiographic findings in these cases may be marked, minimal, or absent. Minimal findings consist only of loss of normal curvature. Marked changes include loss or reversal of curvature, narrowing of the disk space, and hypertrophic spurring about the margins of the vertebral bodies anteriorly and about the margins of the lateral intervertebral joints posteriorly. These latter spurs extend into the intervertebral foramina. It is important to remember that in a substantial number of patients, the roentgenograms will show a normal cervical spine.

Gratifying relief can be anticipated from conservative treatment in a high percentage of cases.

One diagram.

THE CHEST

Broncho-pulmonary Segmental Anatomy and Bronchography. Chauncey N. Borman. Minnesota Med. **41:** 820–830, December 1958. (250 Medical Arts Bldg., Minneapolis, Minn.)

Radiologists are often called upon to localize a lesion within a lung. Accurate localization, in anticipation of surgical resection, requires familiarity with bronchial distribution and bronchial supply. Bronchopulmonary segment anatomy and terminology are described by the author, following the Jackson-Huber system (Dis. of Chest **9:** 319, 1943), with Boyden's addition (Boyden, E. A.: Segmental Anatomy of the Lung. New York, McGraw-Hill Book Co., 1955). The use of this system of nomenclature by the clinician, radiologist, pathologist, and surgeon is advised for standardization and simplicity. Familiarity with the appearance and location of pulmonary segmental densities on the plain film and with the normal pattern of the bronchial tree as shown on bronchograms is a basic fundamental for interpretation and evaluation of bronchopulmonary disease.

The author discusses briefly the technic and media used in bronchography. The bronchographic findings in several disease conditions are also listed.

Fourteen roentgenograms; 8 diagrams; 1 table.

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The Art and Science of Bronchography in Infants and Children. Duane L. Merrill and Paul C. Samson. Ann. Otol., Rhin. & Laryng. **67:** 1126–1140, December 1958. (459 30th St., Oakland, Calif.)

This article is based on 92 bronchographic examinations in children performed over a five-year period. Bronchograms are obtained under a combination of light general endotracheal ether anesthesia and topical xylocaine. Oily Dionosil is instilled into a catheter which has been threaded through the indwelling endotracheal tube to a point just above the carina; 5 to 10 c.c. is usually adequate for a satisfactory study of one lung and as much as possible should be aspirated through the catheter at the termination of the examination. Examination of the other lung may then be carried out if indicated. To obtain precise diagnostic films with minimum hazard to the patient, the utmost in teamwork and speed is required of the radiologist, anesthetist, and surgeon.

Ferguson and Flake (J.A.M.A. **164:** 518, 1957. Abst. in Radiology **70:** 606, 1958) have discussed the clinical symptoms which may require the aid of bronchography. They list roentgen evidence of chronic pulmonary changes, chronic unexplained cough, stridor, recurring localized pulmonary infection, localized wheezing, and hemoptysis. The basic pathology is often best defined by the bronchogram when certain roentgenographic findings are present. Among these abnormalities, atelectasis, persistent pneumonitis, obstructive emphysema, and hemithoracic contraction are particularly important.

While suspected bronchiectasis is the time-honored indication for bronchography, the highest incidence of normal bronchograms was found in this group of patients. Bronchograms were of most value and often decisive in cases of bronchostenosis secondary to intrinsic inflammatory processes, extrinsic compression, congenital anomalies, and after aspiration of foreign bodies. The procedure is of value after removal of a foreign body to define areas of residual bronchiectasis—a frequent and disabling complication.

Nine cases are reported to illustrate the bronchographic findings in various disease processes.

Fourteen roentgenograms.

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Angiocardiography as an Aid to Identification of Nonresectable Pulmonary Carcinomas. Stanley M. Wyman and Earle W. Wilkins, Jr. J. Thoracic Surg. **35:** 452–460, April 1958. (Massachusetts General Hospital, Boston 14, Mass.)

This article is concerned with angiocardiography in the preoperative prediction of resectability of primary carcinoma of the lung. The diagnosis of pulmonary cancer, and the role that angiocardiography may play in it, are not considered.

Examinations were performed initially by the original method of Robb and Steinberg, a concentrated iodine compound being introduced through a No. 12 cannula inserted into and tied in one of the deep arm veins. At first, 50 per cent Diodrast was used, but

this was later replaced by 70 per cent Urokon. Serial roentgenograms were made, originally by a homemade cassette-changing device which permitted 20 exposures at rates up to 3 per second. More recently a biplane roll film changing device has been employed, providing simultaneous anteroposterior and lateral recording at rates up to 12 frames per second in each projection. Most examinations were done at the rate of 6 frames per second for two or three seconds, followed by 2 per second for an additional five or six seconds, and finally 1 per second for a total run of fifteen to twenty seconds. The method of injection has also been changed, as experience dictated, with use of a No. 11 or 12 Lehman catheter introduced *via* the deep veins of the arm on the affected side into the corresponding innominate vein, and the contrast material injected by means of a central-bore Robb hand-operated syringe. The method has been quite satisfactory, permitting the introduction of between 50 c.c., and at the most 70 c.c., of 70 per cent Urokon in less than two seconds. This part of the examination was performed by the surgeon with the radiologist determining the proper positioning of the patient in addition to other radiographic factors.

Twenty-four examinations were carried out in 23 patients with primary carcinoma of the lung, without serious incident. (Patients with evidence of cyanosis, recent myocardial infarction, asthma, or serious allergy were not accepted for this investigation.) Findings were checked at surgical operation.

The following angiocardiographic evidence was found of aid in predicting unresectability.

1. Occlusion or a severe degree of narrowing of the left pulmonary artery within 1.5 cm. of its origin from the undivided pulmonary artery. Such involvement precludes separation of the branch vessel from the trunk. Complete occlusion of the vessel usually is demonstrated by a tapering or pointed ending seen best in the lateral projection.
2. Occlusion or severe narrowing of the branches of the right pulmonary artery to the upper or lower lobes within 1 cm. distal to the bifurcation of the right pulmonary artery, just outside the pericardium.
3. Partial or complete obstruction of the innominate veins of the superior vena cava. It is quite possible to resect such structures, replacing them with venous grafts, but to date this has not been found advisable.
4. Involvement of the major pulmonary veins or the left atrium. Normally the left atrium is smooth and regular in outline, but in 6 cases in this series an irregular filling defect, usually measuring 1 to 3 cm. in diameter, was visible in the heart chamber. In every instance this occurred on the same side as the primary tumor, most commonly at the superior angle near the point of entry of the superior vein, but in 1 case at the point of entry of the inferior pulmonary vein.

Pericardial invasion by tumor was not observed in the present series except as a finding coincident with atrial invasion.

On the basis of the angiocardiographic findings, 13 of the lung cancers in this series were considered unresectable, and this was confirmed in 11 instances.

In 10 cases, no evidence was found which indicated involvement of heart and great vessels; 7 of this group proved operable and 3 were unresectable.

The authors believe that unnecessary thoracotomies may be avoided in patients with lung cancer shown by angiocardiography to be unresectable.

Four roentgenograms; 1 table.

Cavitary Carcinoma of the Lung. Morris M. Culiner, Jacob Abouav, and Stanley B. Reich. California Med. **89:** 355–358, November 1958. (450 Sutter St., San Francisco 8, Calif.)

The authors report 5 cases of squamous-cell carcinoma of the lung visualized roentgenographically as a cavitary lesion of indeterminate cause at the time of initial examination. Two patients died; a third had a right upper lobectomy after the pathologist reported the frozen section to be malignant; and the remaining 2 had nonresectable tumors. In one of the latter, the superior vena cava was involved, and in the other, the aortic arch made up one wall of the tumor cavity. In all, the cavitation resulted from central degenerative changes within the tumor mass.

The clinical course and the laboratory data were variable. Symptoms were absent or simulated those of acute nonspecific inflammatory processes.

When confronted by such pictures, the authors advocate the following procedures: examination of the sputum by smear, culture, and Papanicolaou methods; bronchoscopy and biopsy where indicated; excision of the regional supraclavicular lymph nodes for microscopic examination and for cytologic specimens and culture if specific tuberculous or granulomatous fungous lesions are suspected. In addition, administration of a broad spectrum antibiotic in high dosage should be undertaken as a therapeutic test even though there be no definite evidence of systemic sepsis. The investigative period may be prolonged if truly significant change is demonstrated radiologically following antibiotic administration, but thoracotomy should not wait upon the results of cultures and guinea-pig inoculations; in the absence of roentgen change, surgery should be carried out promptly to establish a diagnosis and to permit whatever excisional therapy is possible.

Six roentgenograms.

Endoscopic Aspects of Primary Tuberculosis in Children. John F. Daly. Ann. Otol., Rhin. & Laryng. **67:** 1089–1105, December 1958. (140 E. 54th St., New York, N. Y.)

In the course of primary tuberculous infection in children, dense homogeneous shadows are seen within the lung parenchyma, representing airless lung. The right middle lobe and the anterior segment of the right upper lobe are the most common sites of involvement. It is the general consensus of opinion that the basic pathology is an atelectasis due to bronchial obstruction. This condition is sometimes called "epituberculosis."

The author reports a combined clinical and bronchoscopic study of 156 children with proved tuberculous endobronchitis to investigate the bronchial changes in pulmonary tuberculosis and to assess their role in producing such changes in the lung as consolidation, atelectasis, and emphysema. Homogeneous shadows indicating bronchial obstruction of a segment or lobe were present in all but 15 of the 156 patients.

The pathologic changes in a bronchus cause definite changes in the segment of the lung to which it is distributed. In some instances, either by compression or the presence of a polyp, a check-valve mechanism is set up and emphysema of varying extent results. The obstruction usually becomes complete, and atelectasis results. In the roentgenogram, the atelectatic segment may appear as a homogeneous shadow, typical of airless lung tissue diminished in volume. Frequently the lobe or segment does not decrease in volume. This is

due to distention by retained secretions. The ulceration of the mucosa stops ciliary activity and the peribronchial inflammation prevents contraction of the bronchus, thus the two mechanisms for moving secretions out of the bronchus are interfered with. The bronchi heal by fibrosis, which, in the final stages, causes stenosis, distortion, and dilatation, *i.e.*, bronchiectasis.

Permanent changes were assessed by plain films and bronchograms. The latter furnished the best evidence of damage to the bronchi. In 70 of 103 children the bronchographic findings were abnormal.

Antituberculous medication failed to alter the course of the endobronchial lesions or to prevent development of bronchiectasis and pulmonary fibrosis.

One diagram; 7 tables.

MAJ. MARTIN A. THOMAS, M.C.
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Rheumatic Pneumonitis. Part II. Report on the Clinical and Laboratory Findings in Twenty-Three Patients. David Goldring, M. Remsen Behrer, George Brown, and Gladden Elliott. J. Pediat. **53:** 547–565, November 1958. (Washington University School of Medicine, St. Louis 10, Mo.)

The findings in 23 patients with rheumatic pneumonitis, seen in the past eight years, are presented. The clinical course of each of the patients was analyzed. Electrocardiograms and serial roentgenograms were studied when available. All of the patients were treated in essentially the same manner.

Nonsurvivors: Chest roentgenograms were obtained of 12 of the 16 patients who died. All but 1 revealed definite cardiac enlargement, usually generalized and of a marked degree. Only 10 of the 12 patients showed evidence of pneumonia. Seven of this number exhibited diffuse, homogeneous zonal infiltrates variously occupying the inner, middle, and outer thirds of the lung fields. This infiltrate was usually bilateral and was characterized by a clear zone about the hilus. The appearance was similar to that in so-called "azotemic pneumonia" or "acute pulmonary edema." Segmental or lobar infiltrates suggesting organization or infarction were demonstrated in 2 patients. In 1 patient both types of infiltrate seemed to occur. Although subsequent pathologic examination of the specimens revealed instances of these distinct types of infiltration, the correlation with the roentgen findings was poor.

Survivors: Numerous chest roentgenograms were available for the 7 patients who survived. Six had generalized cardiac enlargement. In most of these the heart seemed to enlarge during the pneumonic phase, decreasing in size only slightly as the patient's condition improved. All 7 patients exhibited pneumonia on roentgen examination—4 zonal, 1 segmental, and 2 a combination of the two types. All cleared completely over periods of one to four weeks. The authors believe that rheumatic pneumonitis is associated with the severe form of rheumatic fever. It is a serious threat to survival, and those patients who do survive are left with severe residual heart disease. There is a suggestion that hormone therapy may increase the chance of survival in the child with rheumatic pneumonitis and may possibly decrease the severity of the residual heart lesions.

Four illustrative cases are reported.

Twenty-two figures, including 14 roentgenograms; 3 tables.

Broncho-Pulmonary Amoebiasis. M. Abdel-Hakim and A. M. Higazi. Dis. of Chest **34:** 607–620, December 1958. (Cairo University, Cairo, Egypt)

The authors record their clinical experiences with bronchopulmonary complications of amebic colitis. Amebiasis is primarily an infection of the colon, but its complications may dominate the clinical picture. There are two routes of pulmonary infection: (1) "primary," where the amoeba reaches the lung by direct embolism from the bowel, through the middle and inferior hemorrhoidal veins, (2) secondary, with spread from the bowel to the liver through the portal circulation and then to the lung, either by direct extension through the diaphragm or through the hepatic veins to the inferior vena cava, to the right heart, and by way of the pulmonary arteries.

The incidence of pulmonary involvement has been variously reported. The authors believe, on the basis of their clinical experience, that it is of less frequent occurrence than formerly, possibly because of improved treatment of the original infection.

The clinical manifestations depend upon the type of pulmonary involvement, simulating bronchopneumonia or tuberculosis in the "primary" cases and consisting in the characteristic suppurative syndrome when secondary to rupture of a liver abscess.

The roentgen findings include obliteration of the costophrenic sinuses, pleural effusion, and pneumonic consolidation with or without abscess formation. Vertical linear shadows extending from a localized bulge in the diaphragm into the lung, as well as transverse bands of focal atelectasis, have been described.

The authors' series included 28 cases: 9 with lung abscess; 9 with pneumonitis; 2 with bronchitis; 5 with serous pleural effusion; 3 with empyema. Twenty-two cases were secondary to amebic hepatitis or liver abscess and 6 were "primary" pulmonary infections. The presenting symptons were pain in 24 (86 per cent), hemoptysis in 17 (61 per cent), cough and mucopurulent sputum in 11 (39 per cent), and dyspnea in 3 (11 per cent). The diagnosis is based on the history, right basal localization, character of the sputum, associated liver condition, and the dramatic response to emetine hydrochloride.

Six roentgenograms; 3 tables

HENRY K. TAYLOR, M.D.
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Pulmonary Aspergilloma. Paul F. Hausmann. J. Thoracic Surg. **35:** 538–541, April 1958. (Milwaukee Hospital, Milwaukee, Wis.)

A case of pulmonary aspergilloma in a 52-year-old woman with an extraocular sixth nerve palsy and transient diplopia is reported. Roentgenography of the chest showed a normal heart and mediastinum with minimal calcified areas in the right apex, interpreted as old healed calcified tuberculosis. There was an increased density in the left upper lobe which appeared to be a cavity almost filled with a solid homogeneous substance that shifted in the upright and decubitus positions. The roentgen picture was so similar to that in 7 previously recorded cases of pulmonary aspergilloma (see, *e.g.*, Radiology **66:** 9, 1956) that the diagnosis was made on roentgenograms of the chest alone, and confirmed by bacteriologic studies. Cure was effected by lobectomy and segmental resection. The diplopia has not recurred since the operation.

Two roentgenograms.

Pulmonary Alveolar Proteinosis: A Progressive, Diffuse, Fatal Pulmonary Disease. Coyt R. Payseur, Benjamin E. Konwaler, and LeRoy Hyde. Am. Rev. Tuberc. **78:** 906–915, December 1958. (VA Hospital, Long Beach, Calif.)

Pulmonary alveolar proteinosis is a rare progressive, diffuse pulmonary disease in which the alveoli are filled with an eosinophilic material which is apparently a mucoprotein. The cause is not known, although the suggestion has been made that the disease may be related to inhalation of pulmonary irritants.

A case of this disease is reported in a 44-year-old white male who had far advanced pulmonary tuberculosis in 1953 which responded well to antituberculous drugs. A cavity in the right upper lobe had closed, and the extensive disease cleared except for a few apical infiltrates. Three years later, in April 1956, a routine chest roentgenogram revealed diffuse pulmonary density in the lower perihilar areas bilaterally, extending well into the periphery at the medial bases. The patient was asymptomatic at that time and no acid-fast organisms could be demonstrated by culture or guinea-pig inoculation. A roentgenogram five months later disclosed considerable progression of the infiltrative process, resulting in density in the lower two-thirds of both lung fields. Minor apical fibrotic residues persisted in the right apex. The roentgen changes progressed and in April 1957, only a small amount of aerated, relatively normal appearing lung was noted at the extreme apices and bases. The final film, taken the day prior to death, revealed the process involved both lungs so that scarcely any aerated lung could be visualized.

Microscopic study of the necropsy specimen showed the alveoli to be filled with amorphous material in which there were very few inflammatory cells. Only a few inflammatory cells were noted in the alveolar walls. No significant fibrosis was demonstrated. Various stains showed the material in all probability to be a mucoprotein, but a small amount of lipid material and some foam cells were seen in the alveoli as well as in the interstitial tissues. No granulomas were present.

The clinical picture was that of progressive pulmonary insufficiency resulting in increasing dyspnea and cyanosis. Death occurred thirteen months after the initial roentgenographic findings were observed, at which time the patient was asymptomatic.

Five roentgenograms; 8 photomicrographs.

JOHN H. JUHL, M.D.
University of Wisconsin

Changes in the Chest Roentgenogram in Collagen Diseases. W. Bessler. Radiol. clin. **27:** 330–341, November 1958. (In German) (Johns Hopkins Hospital, Baltimore, Md.)

The chest findings are reviewed in 45 patients with disseminated lupus erythematosus, in 28 with generalized scleroderma, and in 13 with periarteritis nodosa. While none of these diseases has a pathognomonic chest roentgenogram, characteristic findings make an important contribution to the specific diagnosis.

Early pleural and pericardial involvement, the frequent presence of pneumonia with atelectasis, and rapid change in the x-ray findings are characteristic of lupus erythematosus. Progressive lung fibrosis is typical of scleroderma. Involvement of the heart and pulmonary vasculature, transient allergic pneumonitis, and in particular cases granulomatous lung infiltrations are associated with periarteritis nodosa.

Seven roentgenograms; 1 schematic drawing; 1 table.

CHRISTIAN V. CIMMINO, M.D.
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Surgical Treatment of Some Pulmonary Conditions in Childhood. M. L. Cantlin, C. Jules Rominger, and Ward D. O'Sullivan. J. Pediat. **53:** 432–440, October 1958. (Misericordia Hospital, Philadelphia, Penna.)

Childhood respiratory infections are so common that specific explanations for them are rarely sought. Such a search with repeated severe infections may be rewarding. Within a recent twelve-month period, 4 different intrathoracic lesions in children (congenital pulmonary cyst; bronchogenic cyst; congenital lobar emphysema; double aortic arch) were encountered at the Misericordia Hospital (Philadelphia). Three of the lesions had caused repeated pulmonary infections and respiratory distress. The fourth, although producing no symptoms at the time of discovery, would soon have become evident because of the rapid encroachment upon remaining normal pulmonary tissue.

Standard roentgenograms of the chest revealed the pulmonary cyst and the lobar emphysema. In the case of the bronchogenic cyst, a conventional chest film gave no clue to the existence of the lesion. Because the respiratory infections were severe and recurrent, further studies were carried out. Bronchoscopy was helpful in a negative way. Bronchography was of aid but not diagnostic. An esophagram, however, clearly outlined the cyst. In the remaining case a chest roentgenogram was normal, but an esophagram disclosed a constant narrow extrinsic defect in the esophagus posteriorly at the level of the aortic arch and a defect in the anterior tracheal wall at the same level. A diagnosis of double aortic arch or other "vascular ring" was made; on exploration a double aortic arch was found.

Surgical correction of the basic lesion resulted in cure in all of the cases. It is suggested that roentgen diagnostic studies be performed in children with repeated unexplained pulmonary infections.

Six roentgenograms.

Radiologic Aspects of Pleural Effusions in the Nephrotic Syndrome and Glomerulonephritis in Childhood. Cesare Cavina and Gianfranco Vichi. Ann. di radiol. diag. **31:** 163–202, 1958. (In Italian) (Università di Firenze, Florence, Italy)

In a group of 434 children studied by the authors, 52 suffered from the nephrotic syndrome and 382 had glomerulonephritis. Pleural effusions were demonstrated in 11 of the patients with the nephrotic syndrome (an incidence of 21.15 per cent), but in only 8 of the 382 patients with glomerulonephritis (2.35 per cent). The 19 cases are reported in detail. Forty boys and 12 girls composed the group of 52 patients with the nephrotic syndrome; in only 1 of these girls did pleural effusion develop.

The fluid was limited to the right side in 4 patients, to the left in 5; it was bilateral in 10. In 12 of the 19 cases the effusion had an atypical location. In the majority of these it was between the diaphragm and lung, resembling elevation of the diaphragm; in 1 patient it was in the mediastinal pleural space, and in another in the major fissure. Only 2 patients had concomitant pericardial effusions and 5 had ascites.

Twenty-two roentgenograms; 4 drawings; 1 table.

ALEXANDER R. MARGULIS, M.D.
Washington University, St. Louis, Mo.

Experimental Pulmonary Emphysema. Production of Emphysematous Bullae in the Rabbit by Infection with Tuberculosis. John W. Bell. Am. Rev. Tuberc. **78:** 848–861, December 1958. (VA Hospital, Seattle, Wash.)

The development of large pulmonary cysts or bullae has been observed in infected rabbits by observers working with the various antituberculous drugs. The present study was undertaken to determine the role of this chronic infection in the production of obstructive emphysema. Twelve rabbits were infected intratracheally and were treated with streptomycin, PAS, and cycloserine to prevent rapid death from tuberculous pneumonia. The animals were then sacrificed or allowed to die when roentgen evidence of bullae was observed. Only when the tuberculous pneumonia resolved following treatment was emphysema produced. The emphysematous bullae did not usually appear before thirty days post-infection.

Weekly roentgenograms of the lungs were obtained, beginning in the second week, and the development of the bullae could be demonstrated. The roentgen appearance was similar to that noted in human pulmonary tuberculosis with associated emphysematous changes. Gross inspection also showed a comparable picture, with bullae varying in size from small peripheral blebs to giant air spaces replacing nearly an entire lobe. The area of change was seen most commonly in the dorsal portions of the lobe corresponding to the apical location in the human. The emphysematous bullae were clearly identified and readily differentiated from cavities by their smooth thin walls in contrast to the irregular thick infected walls of cavities.

Microscopic examination was made by means of serial sections, approximately four hundred and fifty sections being examined per lung. Vinyl acetate plastic corrosion specimens were made to outline the bullae in the lungs of several animals showing emphysematous change. These casts are shown in photographs and clearly demonstrate the marked emphysema. The serial microscopic sections revealed bronchiolitis, vasculitis, and peribronchial pneumonia in those rabbits sacrificed prior to the development of emphysematous bullae. Later, about a month after the infection, the bullae were observed and the histologic precursors were found in the enlarging subpleural foci with ruptured septa. Narrowed bronchi were often observed, occluded with exudate and amorphous material.

It appears likely from this study that the emphysematous process begins with tissue damage resulting in obstruction of bronchi and bronchioles, often with a one-way valve type of obstruction leading to overdistention of alevoli and coalescence with break down of alveolar and septal walls.

Five roentgenograms; 12 photomicrographs; 7 photographs; 1 table. JOHN H. JUHL, M.D.
University of Wisconsin

THE HEART AND BLOOD VESSELS

Combined Auricular and Ventricular Septal Defects: A Study of Five Cases, with Postmortem Confirmation in Three. J. Espino-Vela, B. Portillo, V. Rubio, and S. Aranda. Am. Heart J. **56:** 856–866, December 1958. (Instituto Nacional de Cardiología, Mexico, D. F.)

Both auricular septal and ventricular septal defects are frequently associated with other congenital anomalies. The association of these two defects with each other, however, is apparently unusual. Five cases of this coincidence are reported here, and the importance of clinical, radiologic, and electrocardiographic observations before resort to specialized studies is evaluated.

In the 3 cases coming to autopsy the auricular septal defect—a patent foramen ovale—appeared to be the result of excessive resorption of the septum primum and faulty development of the septum secundum. The defects were highly placed. The ventricular septal defects were attributed to lack of development of the pars membranacea. The same embryologic defects were assumed to exist in the cases not proved by postmortem studies.

Radiologically, varying degrees of cardiomegaly were observed, due to hypertrophy and dilatation of the right cardiac chambers and, to a slight extent, of the left ventricle. The left side of the heart is usually not enlarged in isolated auricular septal defects, while this is a usual finding in ventricular septal defects. In all cases the pulmonary artery and hilar shadow were enlarged due to a left-to-right shunt. Angiocardiography was useful, demonstrating both defects in one of the cases.

Electrocardiographic findings were not pathognomonic, since the pattern is similar to that seen in atrioventricularis communis.

At catheterization the auricular septal defect was entered with the catheter in one instance. The cases mimic atrioventricularis communis, since two oxygen step-ups were found, one at the auricular level and one at the ventricular level.

Six roentgenograms; 2 photographs; 2 electrocardiograms; 2 tables. ROGER M. STOLL, M.D.
New York, N. Y.

Right Heart Catheterization in Infants and Children. Analysis of Data Obtained in the Study of 218 Patients. Burton W. Fink, Arthur J. Moss, Forrest H. Adams, and Bernard J. O'Loughlin. J. Pediat. **53:** 566–570, November 1958. (University of California at Los Angeles, School of Medicine, Los Angeles 24, Calif.)

An analysis of 218 right heart catheterizations performed in infants and children at the Medical Center of the University of California at Los Angeles is presented. Eighty-five of the patients were under two years of age, and 65 of these were less than a year old. The catheterization was performed under fluoroscopic control using an image amplifier, with lead screening strategically positioned in order to offer the maximum protection to the operating personnel. The pulmonary artery was entered in 73 per cent of the children under two, and the left atrium in 51 per cent. The corresponding figures for the total of 218 studies were 79 and 38 per cent. The procedure was found to be reasonably safe, even in small infants who were critically ill.

Assuming that the findings at surgery represented the correct anatomical diagnosis, the clinical impression based upon history, physical examination, roentgenography, and electrocardiography was accurate in 74 per cent of the examinations. The additional information gained by cardiac catheterization increased the accuracy of the diagnosis to 91 per cent. The authors believe that this procedure is invaluable and that it should be utilized in selected cases regardless of the age or the physical condition of the patient.

One photograph; 4 tables.

Value of Angiography in the Diagnosis of Hydatid Cysts of the Heart. Lavaurs and Gras. J. de radiol. **39:** 809–814, December 1958. (In French) (Clinique cardiologique Cantini, Marseilles, France)

In roentgen studies of hydatid cysts of the heart, localized bulges in the myocardium may be seen in one view or another, and occasionally there may be calcification in the cyst wall. At times the patient's history and findings such as the electrocardiogram are helpful. There are still some cases, however, in which doubt remains. The authors present 2 cases in which angiocardiography demonstrated the filling defect in the region of the left ventricle.

Twelve roentgenograms.

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Tulane University

Use of Biplane Cinefluorography for Measurement of Ventricular Volume. Carleton B. Chapman, Orland Baker, Jack Reynolds, and Frederick J. Bonte. Circulation **18:** 1105–1117, December 1958. (University of Texas Southwestern Medical School, Dallas, Texas)

A complicated but seemingly quite accurate method of measuring ventricular volume is presented, with biplane cinefluorography as the basic procedure. Ventricular outlines are traced from images projected to the original size and cross-sectional planes constructed at each millimeter from top to bottom. The volumes of the successive cross sections are calculated (on the assumption that the cross-sectional outline of the ventricle is elliptical or circular and that the two figures record a major and minor axis of the ellipse) and are summed up to give the ventricular volume. The method was checked by measuring the image of a spinning opaque object of known volume and proved to be 99.5 per cent accurate.

Radiation exposure for human subjects was considerable, since 360 exposures are made in each projection in a six-second run (30 frames per second, each frame receiving 2 exposures, 1/120 second apart, at 200 ma and 130 kv). With filtration of 0.25 mm. Cu and 2.0 mm. Al the dosage received was 9 r from the posteroanterior tube and 17 r from the lateral tube.

Timing of the film is done in relation to the cardiac cycle so that changes in volume in various phases can be measured. The method promises to be of value in physiologic research, but obviously, because of the radiation hazard plus the fact that as many as 25,000 individual measurements must be made for a six-second run, it will not soon become a common procedure.

Thirty-six figures including 27 roentgenograms; 5 tables.

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Kinking of the Aortic Arch. B. F. Vaughan. Proc. Coll. of Radiologists of Australasia **2:** 46–50, September 1958.

The author reviews the literature on kinking of the aortic arch and adds 3 cases of his own. This is an uncommon congenital abnormality which results in an aortic deformity similar to coarctation of the aorta but without any manifestations of vascular obstruction. The condition is thought to be produced by an excessive contraction of the ductus arteriosus pulling part of the aortic arch toward the pulmonary artery, thus producing a "kink." In the postero-anterior view, the high aortic arch casts a round or crescentic shadow projecting to the left of the superior mediastinum, sometimes suggesting a mediastinal tumor. The aortic deformity may bear radiological resemblance to coarctation, although no rib notching or ventricular enlargement is noted. Systolic murmurs are frequently present and may give rise to an erroneous diagnosis of organic heart disease.

This condition has previously been referred to as pseudocoarctation or subclinical coarctation, but the author prefers "kinking," since the former terms imply a relation to coarctation and this is not definitely established.

Three cases are reported, in none of which were there symptoms referable to the cardiovascular system. In the postero-anterior view with barium in the esophagus, the aortic esophageal impression was noted to be higher, deeper, and longer than usual in 2 cases. It was normal in 1 case, since only the posterior portion of the kinked aortic arch was in relation to the esophagus. In the left anterior oblique view the author thought it was apparent that the abnormal shadow was due to a high anterior portion of a kinked aorta and this was confirmed by the right anterior oblique view. Lateral tomographs further substantiated the origin of the deformity.

Most of the previous reports have used angiocardiography and thoracotomy for demonstration of the lesion, but the author believes that the diagnosis may be made by means of plain radiography in various projections, tomography, and fluoroscopy with barium swallow.

Six roentgenograms. ROBERT C. MCLANE, M.D.
Bowman Gray School of Medicine

Corrected Transposition of the Great Vessels of the Heart. J. A. Kernen. Am. Heart J. **56:** 583–590, October 1958. (Indiana University Medical Center, Indianapolis, Ind.)

In "uncorrected" transposition of the great vessels the aorta arises from the right ventricle and the pulmonary artery from the left ventricle. The anteroposterior relation of the aorta and pulmonary artery is reversed, the aorta being anterior and to the right of the pulmonary artery. They run parallel to each other and do not cross in the usual manner.

In corrected transposition, the origin of the aorta is from the ventricle on the left side and that of the pulmonary artery from the ventricle on the right. The aorta thus arises to the left of the pulmonary artery. The two vessels, however, are related to each other in the anteroposterior plane as in "uncorrected" transposition, even though the venous connections are normal; the aorta is anterior to the pulmonary artery (instead of in the normal posterior position), and the two vessels run parallel without crossing.

This condition does not result in any disturbance of physiology. Most of these cases, however, are associated with other cardiac anomalies. Usually a localized situs inversus of the ventricle is present, in which the left ventricle possesses the morphologic features of the right ventricle, and vice versa. An inversion of the coronary arteries may also occur.

Chest films in cases reported by the author showed generalized cardiac enlargement with accentuation of the pulmonary vascular markings. Angiocardiography in 2 of the cases showed a left-to-right shunt with counterclockwise rotation of the great vessels and the aortic arch to the left of the pulmonary artery.

Two figures. ROGER M. STOLL, M.D.
New York, N. Y.

Spontaneous Aneurysm of the Ductus Arteriosus. A Review and Report of the Tenth Adult Case. Bruce Cruickshank and R. M. Marquis. Am. J. Med. **25:** 140–149, July 1958. (B. C., Department of Pathology, Royal Infirmary, Glasgow, Scotland)

The physical, radiological, and pathological findings in a 58-year-old woman who presented with clinical evidence of an aortic aneurysm and died as the result of rupture of an aneurysm of the ductus into the esophagus are described. This is believed to be the tenth adult case reported, but the authors think the lesion is probably less rare than the medical literature would indicate. Their case is analyzed in conjunction with the findings in the 60 recorded cases of spontaneous aneurysm of the ductus of which 51 were in infants. The nature and pathogenesis of the aneurysm are basically similar in the two groups. It arises as a fault in the closure of the ductus. The lesion in the infant is usually found incidentally at autopsy, and is unrelated to death; in the adult it most frequently presents as a mediastinal tumor.

None of the clinical features is diagnostic, but any combination of cough, hemoptysis, dyspnea, and pain in the chest indicates the need for radiologic examination, upon which the diagnosis of aneurysm of the ductus is almost exclusively based. The aneurysm is evident radiologically as a mediastinal tumor in the region of the main pulmonary artery. It may lie posterior or anterior to the trachea, usually displacing it to the right. Expansile pulsation may or may not be present and is not necessary for diagnosis. A rim of calcification in the periphery of the lesion is characteristic, but postoperative cases show that this may take a year or two to develop. If calcification is present, this may raise the question of an aneurysm, but a similar picture may be produced by any dissecting aneurysm in this region, whether spontaneoous or traumatic. Location of the aneurysm posterior to the trachea has been taken as indicative of aneurysm of the ductus, but is not diagnostic. In the authors' case the location was anterior and an anterior position has also been reported in the infant. The lung adjacent to the aneurysm may reveal radiologic signs of consolidation due to compression, fibrosis, or hemorrhage. This was a striking feature in the authors' case. In postoperative cases the same type of radiologic appearance has been seen, and may vary with occurrence of hemoptysis. Angiocardiography may aid in the diagnosis, as in dissecting aneurysms of the aorta. Cardiac catheterization is probably unwise in view of the frequency with which the aneurysm contains a thrombus. When pain is severe, electrocardiography may be of value in excluding recent myocardial infarction.

Some aneurysms of the adult type should be amenable to surgical treatment.

Two roentgenograms; 2 photographs; 1 electrocardiogram.

Arteriographic Studies of the Coronary Arteries in Ischemic Heart Disease. Alan P. Thal, L. Stephen Richards, Richard Greenspan, and M. John Murray. J.A.M.A. **168:** 2104–2109, Dec. 20, 1958. (University of Minnesota Medical School, Minneapolis, Minn.)

The authors describe a recently developed technic which permits good visualization of the coronary circulation in unanesthetized patients. The patient is premedicated with Demerol and atropine and a polyethylene catheter is introduced into the brachial artery. Under fluoroscopic guidance the catheter is advanced into the ascending aorta and positioned 2.5 cm. above the aortic valve; 30 to 50 c.c. of 90 per cent Hypaque solution is injected within 0.8 to 0.6 seconds, by means of a mechanical injection apparatus (see following abstract). A special apparatus has been developed for proper timing of injection to begin with cardiac systole and continue for one cardiac cycle Serial films are obtained in two planes.

The most definite sign of coronary arteriosclerosis seen on angiography is a complete or partial occlusion of a major vessel. This is most common in the proximal reaches of the anterior descending branch of the left coronary artery and may be manifested by gradual tapering of the vessel, by abrupt occlusion, or by atheromatous encroachment on the lumen. Evidence of collateral circulation may appear.

Four illustrative case histories are given. Two of the patients were referred for possible cardiac surgery, but the findings on coronary arteriography were normal, and the symptoms disappeared or decreased when the patients were informed of this finding.

The value of coronary arteriography, apart from investigation, is in elucidating difficult clinical problems and providing objective evidence of coronary disease prior to myocardial revascularization.

Nine roentgenograms; 3 diagrams.

J. S. ARAJ, M.D.
Toledo, Ohio

Phasic Dye Injection Control System for Coronary Arteriography in the Human. L. Stephen Richards and Alan P. Thal. Surg., Gynec. & Obst. **107:** 739–743, December 1958. (University of Minnesota Medical School, Minneapolis, Minn.)

The authors have previously described the performance of coronary arteriography (Thal *et al.*: Surg., Gynec. & Obst. **105:** 457, 1957. Abst. in Radiology **71:** 284, 1958). They here report the injection technic as further developed and now being used in man (see also preceding abstract). The device employed consists briefly of a compressed nitrogen-driven syringe and an electronic injection control system triggered by the R wave of the electrocardiogram. The control system was specifically designed to allow injection of the medium at variable times during the cardiac cycle for any desired duration and at any desired rate of flow. This is accomplished by means of a suitable delay mechanism and variable injection pressures. Preliminary carotid compression is performed to determine the patient's tolerance and the effect on cardiac rate.

The injection is done by way of a catheter during carotid compression to decrease the cerebral circulation of the medium. Films are taken on a biplane rapid-change x-ray device which is capable of taking six pictures per second at an exposure time of 0.01 second. With a large-bore catheter 65 c.c. of 90 per cent diatrizoic acid (Hypaque) may be delivered in one second. Generally, however, only 30 to 45 c.c. are necessary. The pressure used for injection is 150 lb. per square inch and it has been found that during injection there is only a 15 to 35 mm. of mercury increase in the intra-aortic pressure.

Seven figures, including 2 roentgenograms.

L. MURRAY HOUSER, M.D.
University of Pennsylvania

Pulmonary Arteriovenous Fistula Associated with Capillary Telangiectasia (Rendu-Osler-Weber Disease): Report of a Case Illustrating Use of Metal Casting for Demonstrating the Lesion. Israel Steinberg, Bernard Maisel, and F. Stephen Vogel. J. Thoracic Surg. **35**: 517–522, April 1958. (New York Hospital-Cornell Medical Center, New York 21, N. Y.

Pulmonary arteriovenous fistulas are congenital hemangiomatous malformations of the pulmonary vascular bed. In recent years, a close relationship between capillary telangiectasia (Rendu-Osler-Weber disease) and pulmonary arteriovenous fistulas has been recognized. In 16 patients with pulmonary arteriovenous fistulas studied at The New York Hospital, 6 had characteristic mucosal and skin lesions of Rendu-Osler-Weber disease and 2 others, although without capillary hemangioma, gave a familial history of such lesions.

In 6 cases of pulmonary arteriovenous fistula, previously reported (Am. J. Med. **19**: 549, 1955; Am. J. Roentgenol. **78**: 234, 1957. Abst. in Radiology **67**: 295, 1956; **70**: 890, 1958), metallic casts were prepared of the anatomic specimens. The sixteenth case of pulmonary fistula encountered, and the seventh with study of the specimen after casting, is presented here. The patient, a 46-year-old man, had disabling epistaxis due to nasal capillary telangiectases. The diagnosis of pulmonary arteriovenous fistula of the right lower lobe was established by angiocardiography.

The metallic cast of the excised segment of the right lower lobe reveals the complexity of the malformations. Pulmonary arteriovenous fistulas are not merely communications between an afferent end pulmonary artery and vein. Rather they are intricate lesions with centrally dilated, paper-thin globular connections that frequently involve the entire blood supply of the lobe or segment. Also, arterial and venous communications from neighboring chest wall, bronchus, or lung may occur.

Even in the absence of respiratory complaints, excision of a pulmonary arteriovenous fistula is recommended because of the high incidence of brain abscess, cerebral thombosis, and fatal hemoptysis in patients with this condition. The risk from complications is far greater than the mortality and morbidity of lobectomy or segmental lung resection.

Four roentgenograms; 3 photographs.

Aneurysm of the Splenic Artery. W. C. Shands and J. Harvey Johnston, Jr. Arch. Surg. **77**: 970–973, December 1958. (710 N. State St., Jackson 2, Miss.)

Splenic artery aneurysms are rare. The average age incidence is reported as forty-eight years with occurrence twice as common in women as in men. The condition has been frequently seen during the last trimester of pregnancy. Etiologic factors include arteriosclerosis, subacute bacterial endocarditis, congenital aneurysm formation, portal hypertension, syphilis, and trauma.

A case is reported of a 58-year old woman with diabetes and pain in the left upper quadrant of the abdomen. An enlarged spleen had been present for thirty years following her last pregnancy. A plain film of the abdomen showed calcified aneurysms of the splenic artery. Gastrointestinal study disclosed a pressure defect on the posterior wall of the stomach. The spleen and five saccular aneurysms of the splenic artery were successfully removed surgically.

Splenomegaly is reported as occurring in 45 per cent of cases of splenic artery aneurysm. The aneurysms may be felt as palpable masses, at times with a thrill or bruit. Plain films of the abdomen and gastrointestinal study, as in the case reported, frequently give all the necessary information. Translumbar aortography may be helpful in obscure cases.

The treatment consists in surgical removal of the aneurysms and usually also of the spleen, preferably prior to rupture because of the increased risk following that complication.

Two roentgenograms; 2 photographs.

R. P. STORRS, M.D.
Los Angeles, Calif.

Phlebography and Its Significance in the Diagnosis of Disease of the Veins. K. G. Eysholdt. Fortschr. a. d. Geb. d. Röntgenstrahlen **89**: 269–277, September 1958. (In German) (Chirurgische Universitätsklinik Göttingen, Germany)

Before phlebography is undertaken, the localization of the suspected damage should be ascertained with all possible exactness. The contrast material should then be injected as close to the lesion and by as direct a route as feasible. To demonstrate a definite occlusion of a main stem, not only must the vein itself be tested but the collateral circulation also must be checked and be fully visualized. If no collateral circulation can be demonstrated, complete occlusion of the main stem is unlikely. This rule applies to all injections that are made in the direction of the circulation in a horizontally placed patient.

For the visualization of the vena cava, a simultaneous injection is made into both femoral veins. If a postthrombotic partial or complete occlusion of the pelvic veins exists, the collateral channels of the pelvis will be filled. If no obstruction exists, the collateral circulation will not be visualized.

If contrast material is injected into the marrow of the pubic bones, it will travel through the retropubic and obturator veins into the hypogastric and common iliac vein but will not fill the external iliac vein.

In the lower extremities the injection is preferably made into the vena saphena parva along the medial malleolus to demonstrate the deep veins of the calf, or into the bone marrow of the external malleolus. In the latter case both the superficial and the deep veins may be visualized. In acute obstructive conditions the horizontal position of the leg may be preferred. The deep main stems may be demonstrated and sometimes thrombi can be seen as filling defects in the vein. In chronic conditions, however, *e.g.*, if the veins have become widened and sacculated after a thrombosis, the horizontal position will not allow satisfactory filling. The injection should then be made with the leg at an angle of 45 to 60°, so that the contrast material is carried upward against gravity. Films should be taken every minute for four minutes. Normally the veins should be filled within one or two minutes. A delay in the transportation of the medium indicates disturbed function and the pathological changes in the veins can usually be demonstrated.

As contrast material in phlebographic studies the author prefers Urografin.

Phlebography is indicated for noninflammatory swelling of the extremity of unknown etiology, for demonstration of the extent of acute and chronic patho-

logical processes of the main veins, and for testing the function of the veins.

Thirteen roentgenograms.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

Tilt Phlebography of Normal Legs. Frits R. Mathiesen. Acta radiol. **50:** 493–500, December 1958. (Rigshospitalet, Copenhagen, Denmark)

For complete appraisal of the veins of the legs, it is necessary to demonstrate that their valves do not permit retrograde flow. Sometimes when a patient is lying horizontal, normal vein valves will not close tightly, and will permit back-flow if intravenous pressure should be increased.

In tilt phlebography a tourniquet is placed about the ankle (to prevent filling of superficial veins) and, following rapid intravenous injection of contrast material, the body position is quickly changed from horizontal to erect. This raises vein pressure proximal to the valves higher than that immediately distal to the valves and will show valve incompetence if present. The contrast medium is of greater specific gravity than blood and so tends to remain unmixed in a lower part of the vein. Therefore, with competent valves the contrast medium collects above the valves, and x-rays show segmentation of the opaque column.

This method is also useful to demonstrate incompetent communicating veins, which are revealed when filling of superficial veins from deep veins occurs as the injection and tilting are carried out.

In the present study, 27 legs of normal healthy men were examined, in 3 of whom incompetent communicating veins were demonstrated. This seems to indicate that incompetence may occur even though there are no signs or symptoms of venous varices. In addition, the phlebograms of this series revealed the deep muscular veins in the calf region in a higher proportion of patients than previously noted with conventional technics, suggesting this is more likely to be a normal finding than has been supposed.

Four roentgenograms; 2 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

The Value of Intraosseous Venography in Tumors of the Female Pelvis. Franz P. Lessmann and Grace M. Waldrop. Acta radiol. **50:** 501–513, December 1958. (Roswell Park Memorial Institute, Buffalo, N. Y.)

Seventy-one cases with intraosseous injection of Hypaque bilaterally into the greater trochanter area are reported upon in this paper. The purpose of the procedure was to produce opacification of pelvic veins and, by their appearance, to locate lymph node involvement or tumor recurrence in carcinoma of the cervix.

Premedication and local anesthesia were employed, and injections were made through bone marrow needles. About 25 c.c. of Hypaque 50 per cent was injected simultaneously into the medullary cavity of each upper femur. Films were made midway in the course of injection and after its completion. The injections were painful, but other complications were not observed.

In patients with carcinoma of the cervix there was good agreement between the radiographic findings and the surgical findings. Obstruction or displacement of venous channels, formation of collaterals, or stasis of the contrast medium were found to be the principal significant radiological changes.

The examination is felt by the authors to be valuable and worthwhile, and to be the method of choice for demonstration of the parietal-pelvic-venous system.

Eight roentgenograms.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

THE DIGESTIVE SYSTEM

H-Type Tracheoesophageal Fistula. Alden H. Miller. Ann. Otol., Rhin. & Laryng. **67:** 1078–1088, December 1958. (500 S. Lucas Ave., Los Angeles, Calif.)

Congenital tracheoesophageal fistulas of the H-type, *i.e.*, without atresia of the esophagus, are quite rare but being reported with increasing frequency. The characteristic symptomatic triad, with its onset in the immediate postnatal period, consists of (*a*) choking and cyanosis upon feeding, (*b*) distention of the abdomen, and (*c*) recurrent aspiration pneumonitis.

Once esophageal atresia is ruled out by the easy passage of a catheter into the stomach, a contrast swallow is indicated, under fluoroscopic control. Persistence and ingenuity are required for arriving at a diagnosis. It appears that these fistulae are best demonstrated by an aqueous contrast material, such as "Hypaque" or "Urokon" with the patient in the prone or right lateral position.

The fistula is usually situated at a relatively high level, sometimes in the cervical region. The opening of the anterior wall of the esophagus is usually down lower and more widely opened than is the orifice into the posterior wall of the trachea. This results in a characteristic "tea-pot spout" configuration when the fistula is filled with contrast medium.

Endoscopy has been quite unsuccessful in demonstrating this type of fistula.

Three roentgenograms; 2 photographs; 1 diagram.

MAJ. MARTIN A. THOMAS, M.C.
MacDill AFB, Tampa, Fla.

Right Angle Roentgenography of the Gastrointestinal Tract. Samuel L. Beranbaum and Harold G. Jacobson. Am. J. Roentgenol. **80:** 933–944, December 1958. (H. G. J., Montefiore Hospital, New York 67, N. Y.)

The authors advocate routine right-angle views in radiography of the barium-filled gastrointestinal tract, particularly for defining enlargement of adjacent organs and retroperitoneal tumors, and for visualizing some gastric and duodenal ulcers.

In a search for upper abdominal masses the following six exposures are made: postero-anterior upright, left lateral upright for the left retrogastric space, postero-anterior and right lateral recumbent for the right retrogastric space, and anteroposterior supine and translateral supine for the midline component of the retrogastric structures.

The authors believe that, while the measurements of the retrogastric space for individuals of varying habitus determined by Sheinmel and Mednick (Am. J. Roentgenol. **65:** 77, 1951. Abst. in Radiology **57:** 916, 1951) are probably the most valid to date, reliance on mensuration alone will often lead to erroneous conclusions. In a distensible abdomen there are too many variable factors mitigating against the value of fixed measurements.

There are times when simultaneous right-angle study

of the opacified gastrointestinal tract with pyelography can be crucial. In liver enlargement, the stomach is usually displaced backward. The spleen enlarges posteriorly as well as inferiorly, with the posterior enlargement taking place quite early, with indentation of the stomach on its posterior aspect and forward displacement. A right kidney mass will displace the descending duodenal segment forward, indenting the posterior duodenal wall.

Thirty roentgenograms; 1 table.

MAJ. MARTIN A. THOMAS, M.C.
MacDill AFB, Tampa, Fla.

Roentgen Detection of Early Gastric Neoplasm. Report of a Case. Lloyd K. Mark. Wisconsin M. J. **57:** 531–533, December 1958. (Mt. Sinai Hospital, Milwaukee, Wisc.)

The low five-year survival rate in gastric carcinoma indicates the need for early diagnosis. Roentgen study is still our best method for early detection of these cases. Occasionally, however, in spite of early clinical suspicion and careful roentgen examination, the tumor escapes detection, only to be discovered later with widespread growth.

The cardia and fundus present a special challenge for the radiologist due to the variable normal configuration of the mucosal pattern, extrinsic pressure from adjacent organs, and overlying structures rendering this area inaccessible to palpation. A case is reported where a small tumor of the fundus, initially showing trivial and questionably significant x-ray changes, apparently spread in six weeks to involve the entire length and thickness of the stomach wall. This case graphically illustrates the urgency and difficulties of early x-ray diagnosis and the need of roentgen and clinical follow-up examinations in the face of equivocal findings.

Two roentgenograms.

J. S. ARAJ, M. D.
Toledo, Ohio

Early Diagnosis of Malignant Tumors of the Stomach: A Case of Round-Cell Sarcoma. P. Krieg, P. Ryncki, and M. Bugnion. Radiol. clin. **27:** 347–351, November 1958. (In French) (Lausanne, Switzerland)

This is a brief case report with a discussion of early diagnosis of carcinoma of the stomach. The case presented is that of a 46-year-old female in whom postprandial epigastric pain and burning began about four years prior to the first roentgen study. Gastric analysis revealed hyperacidity, and hypertrophy of the antral folds was demonstrated after a barium meal. A few months later it was noted that the symptoms were becoming more severe and were accompanied by vomiting. About one year after the first admission the patient stated that she had lost 6 kg. of weight in the preceding three months.

Four years after the first examination the patient had achlorhydria, and barium meal studies disclosed an area of rigidity in the lesser curvature near the angle of the stomach. The hypertrophic gastric folds had disappeared. At surgery it was found that the rigid area was produced by a lesion measuring 1.0 by 0.5 cm., with slightly elevated edges. Microscopic examination revealed a round-cell sarcoma.

The authors emphasize that careful and repeated observations of patients with gastric disturbances are mandatory if the early malignant lesion is to be discovered. Ulcers that do not heal within two or three months, areas of rigidity in the gastric wall, and a definite change in the gastric mucosa should be considered danger signals. Clinical signs such as weight loss and rapid decline of gastric acid are also important.

Three roentgenograms.

CHARLES M. NICE, JR., M.D., Ph.D.
Tulane University

Postoperative X-Ray Findings Following Cardia Resection and Gastrectomy. G. Beck. Fortschr. a. d. Geb. d. Röntgenstrahlen **89:** 291–300, September 1958. (In German) (Menzinger Strasse 48, München-Nymphenburg, Germany)

Advances in surgery in general, and anesthesia in particular, have opened up the possibilities of much more radical gastric surgery, with resection of the cardia. A clear schematic drawing showing the ten most common operative procedures, followed by a short description of the operations, is reproduced.

The author has found the most common complication following gastric surgery to be insufficiency of one of the suture lines, with a resultant fistula. In 100 postoperative x-ray examinations he discovered 20 fistulous tracts. They usually produce no clinical symptoms and disappear spontaneously after a few weeks, but may on occasion lead to abscess formation.

One of the most difficult problems for the radiologist is the decision as to whether or not cancer is recurring. To answer this question the author makes the following recommendations: (1) Inasmuch as quite complicated anatomical changes may have been produced by surgery, the radiologist should first carefully study the operative record. (2) A routine postoperative roentgen examination should always be insisted upon, about two weeks after the operation and before the patient leaves the hospital. This will serve as a basis for comparison in subsequent examinations. (3) Great stress should be laid on a careful fluoroscopic examination, as the delay in filling during swallowing and the functional behavior during the peristaltic movements may be much more informative than the findings on the film.

Thirty-nine roentgenograms; 1 schematic drawing.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

Giant Duodenal Ulcer. John Dawson. Brit. J. Radiol. **31:** 666–668, December 1958. (Royal Hampshire County Hospital, Winchester, England)

One would expect that the larger the duodenal ulcer, the more easily it would be detected by a barium meal examination. This is true up to a point, but a review of the literature shows that, when the ulcer crater exceeds 2 cm. in diameter, it is likely to be mistaken for the duodenal cap. Of 13 cases of duodenal ulcer exceeding 2 cm. in diameter previously recorded only 5 were diagnosed after a barium meal. All the authors admit to the error of interpreting the ulcer as a normal or slightly deformed duodenal cap. This error occurred also in the first of the 6 cases reported in the present paper.

A giant duodenal ulcer may be discovered in any of three places: (1) on the posterior wall of the duodenal cap, eroding into the pancreas and replacing the posterior wall of the cap; (2) to one side of the cap, simulating a diverticulum; (3) in the second or third part of the duodenum. The first type leads to the most difficulty.

The radiological signs of giant duodenal ulcer are as follows:

1. The pylorus is either patulous or has been entirely destroyed.
2. The giant ulcer crater is constant in size and shape and exhibits no contractions, in contrast to a normal or slightly deformed duodenal cap.
3. The mucosal pattern has been lost over the crater due to stretching of the opposite duodenal wall.
4. A constriction can be seen distal to the ulcer crater and, with the pylorus patulous or absent, it is not impossible to mistake this for a pyloric canal.

The above signs were demonstrated in 3 of the author's cases One case, as mentioned above, simulated a normal duodenal cap, and another a diverticulum of the first portion of the duodenum. In the sixth case the second part of the duodenum was the site of the ulcer.

Eight roentgenograms.

ROSCOE E. MILLER, M.D.
Indiana University Medical Center

Duodenal Stenosis Due to Post-Bulbar Ulcer. A Comparison of Radiological and Surgical Findings. D. E. Paterson and D. M. Hancock. Brit. J. Radiol. **31:** 660–665, December 1958. (Christian Medical College Hospital, Vellore, Madras, S. India)

A post-bulbar ulcer is by definition any ulcer located in the duodenum distal to the apex of the bulb. Most authorities agree that these lesions are rare, probably well below 5 per cent of all cases of duodenal ulceration, and associated with a low incidence of free perforation and a high incidence of hemorrhage.

In reviewing 39 duodenal ulcer cases from South India in which preoperative barium examinations were done, the authors found 5 post-bulbar ulcers. Operative confirmation of the radiological diagnosis was available, and correlations between the two could be made.

Good correlation was obtained between radiological and surgical findings. At operation the distance of the ulcers from the pyloric ring could not be ascertained until the duodenum had been mobilized, and false impressions would have resulted if this had not been done. Duodenal mobilization by Kocher's method was carried out in all cases and supplemented by direct inspection of the interior of the duodenum in those cases treated by segmental (Wangensteen) resection.

Marked deformity and shortening of the duodenum resulted in an ulcer distance of only 3.0 cm. from the pyloric ring in 4 of the 5 cases. Pain was of an atypical variety, often coming on soon after meals. Frequent vomiting of stale food occurred in all cases and often relieved the pain. Duration of symptoms varied from one to twenty years.

At operation these ulcers were active, deeply penetrating, and surrounded by a dense inflammatory mass. They were situated in the superior border of the duodenum, at or close to the superior flexure, whereas the commonly reported site is on the concave border of the duodenum. All were associated with definite evidence of obstruction, but it must be remembered that stenotic cases in South India may reach the hospital in unrepresentative numbers.

Altogether 50 cases of duodenal ulcer were operated upon in the period covered by this study and 5 additional post-bulbar ulcers were found, suggesting to the authors that this condition is frequently met with in hospital practice in South India but that the diagnosis has not been recognized by either radiologists or surgeons due to technical difficulties in demonstrating the relations of these lesions to the pyloric ring and the superior flexure.

Ten roentgenograms; 3 tables.

ROSCOE E. MILLER, M.D.
Indiana University Medical Center

Combined Gastric and Duodenal Ulceration. A Survey of 157 Cases. R. Mangold. Brit. M. J. **2:** 1193–1197, Nov. 15, 1958. (Central Middlesex Hospital, London, England)

One hundred and fifty-seven case reports of combined gastric and duodenal ulcer first diagnosed in 1947–1954 were collected from the in-patient and out-patient clinics of the Central Middlesex Hospital, London. Acute ulcers were excluded from the study and, because of the considerable doubt of exact location of antral, prepyloric, and pyloric ulcers, only those gastric lesions at or above the angulus were included.

In 139 of the 157 cases, both ulcers were demonstrated radiologically. In 6 of the remaining 18 no barium-meal study was performed at any time before surgery or necropsy disclosed the ulcers; in 6 the last radiologic study had taken place two to six years before gastric surgery disclosed an additional ulcer not shown earlier and, judging from the symptoms in the interval, not present at the time of examination. In only 5 patients was one of the ulcers certainly missed. Duodenal scars were found in 4 of these patients, and an active duodenal ulcer in 1, accompanied by a considerable degree of pyloric stenosis. In addition, 1 gastric ulcer was not detected two months before it was found at an emergency operation for bleeding. In no case examined radiologically were both ulcers missed.

The two ulcers were simultaneously active at some time in 98 of the 157 patients, a reflection of the severity of the disease in this series. A symptom-free interval lasting more than a year was present in 41 patients, in all of whom the original ulcer had been in the duodenum. Multiple ulcers occurred 22 times: 2 gastric ulcers in 9 cases, 3 gastric ulcers in 3 cases, 4 gastric ulcers in 1 case, kissing duodenal ulcers in 9 instances. Of the 157 patients, 92 suffered from one or more major complications: hemorrhage in 59 cases (38 per cent); perforation in 22 (14 per cent); hourglass stomach in 9 (6 per cent). Excluding 8 patients with a gastric-duodenal sequence of ulceration, and those in whom gastroenterostomy or vagotomy had been performed, 37 of 131 patients had such evidences of gastric retention as frequent vomiting or weight loss, transitory delay in emptying, or organic pyloric stenosis.

During the eight-year period there were 5 known deaths due more or less directly to ulcers. Eighty-two of the 157 patients underwent one or more operations for peptic ulcer, including simple suture for perforation and gastroenterostomy. Partial gastrectomy was performed in 68 patients; in 8 as an emergency measure for hemorrhage. Forty of these patients were over fifty years of age, and 24 of this number were over sixty.

One chart; 5 tables.

Experiences with a New Contact Laxative in the Preparation of the Colon for Radiological Examination. Richard K. Keogh and Robert G. Fraser. J. Canad. A. Radiologists **10:** 66–69, December 1958. (Royal Victoria Hospital, Montreal, Que., Canada)

The authors report their experience with Dulcolax, a contact laxative developed in Europe and only recently

available in Canada. One hundred and forty-two patients were prepared for radiological examinations of the colon with this new agent, and the results were compared with those in a group of 100 patients prepared with castor oil and cleansing enemas.

Toxicity of the drug was found to be negligible, and no contraindication to its use are recorded. The incidence of distressing side-effects was significantly lower than from castor oil and enemas. Patients receiving both forms of preparation were unanimous in preferring the contact laxative.

Dulcolax is supplied in the form of enteric-coated tablets (5 and 10 mg.) and suppositories. The recommended procedure is to give three 5-mg. tablets and one suppository (10 mg.) the evening preceding the examination and a suppository two hours before examination.

R. S. ORMOND, M.D.
The Henry Ford Hospital

Radiographic Features of Rectosigmoid Endometriosis. Gordon J. Culver, Rubens Marcondes Pereira, and Roy Seibel. Am. J. Obst. & Gynec. **76:** 1176–1184, December 1958. (University of Buffalo School of Medicine, Buffalo, N. Y.)

The roentgenographic findings in 7 cases of endometriosis of the rectosigmoid are reviewed.

In constricting lesions the following changes are usually to be noted: (1) annular narrowing, usually short and eccentric; (2) sharp demarcation of the area of involvement; (3) a lesion that is fixed and tender to palpation under the fluoroscope; (4) intact mucosal folds.

In nonconstricting lesions the findings are different: (1) submucosal tumor with intact mucosa; (2) displacement of the bowel by the extraluminal portion of the mass; (3) localized spastic and irritable segment above and below the lesion; (4) local tenderness to palpation; (5) variation in size of the mass with change in phase of the menstrual cycle.

Carcinoma of the colon is differentiated by demonstration of destruction of the mucosa; diverticulitis offers no problem except for the single peridiverticular abscess; primary pelvic tumors can be differentiated if the primary tumor site is demonstrable.

The authors feel that the roentgen findings in endometriosis are sufficiently characteristic that, when combined with the clinical data, a diagnosis should be possible in most cases.

Thirteen roentgenograms; 1 photograph.

ROBERT L. EGAN, M.D.
University of Texas, Houston

Coproliths (Calcified Appendiceal Calculi) in Children. Frank C. Stiles. J. Pediat. **53:** 741–743, December 1958. (921 16th Ave., Monroe, Wisc.)

At one time appendiceal coproliths (radiopaque calculi) were believed to be quite rare. Berg and Berg (Radiology **68:** 839, 1957), however, found 130 cases recorded in the literature and reported 42 cases of their own, seen over a five-year period. Most writers advise immediate appendectomy whenever a coprolith is found, save possibly in the symptom-free older patient. The author believes that when a radiopaque appendiceal calculus is discovered in a child with abdominal symptoms, and other abnormalities have been ruled out, surgery should be performed immediately; in his opinion, operation is usually indicated even in asymptomatic children.

A coprolith or some other abnormality may be found in the child with vague abdominal pain and therefore a plain roentgenogram of the abdomen is justified. In the differential diagnosis consideration must be given to ureteral or renal calculi, gallstones, phleboliths, calcified mesenteric lymph nodes, and radiopaque medications. Enteric-coated tablets, antacids, and diuretics are said to cast the densest shadows.

The case of a 23-month-old boy with a roentgenographically detected appendiceal calculus is reported. At operation, the appendix was found to have ruptured.

One roentgenogram.

Acute Appendicitis Following Retention of Barium in the Appendix. Millington O. Young. Arch. Surg. **77:** 1011–1014, December 1958. (8445 E. Jefferson Ave., Detroit 14, Mich.)

Barium retained in the appendix may form the nidus for a fecalith which the appendix is unable to extrude. This fecalith may later obstruct the lumen and initiate an acute inflammatory process distal to the point of obstruction. Such retention of barium may be indicative of narrowing of the appendiceal lumen, as by kinking, peritoneal bands, or lymphoid hyperplasia.

Brief summaries are given of 3 cases in which acute appendicitis occurred, with evidence of barium retained from gastrointestinal studies, forming portions of appendiceal fecaliths. In 2 cases appendicitis occurred about ten days after administration of barium (in 1 case orally and in 1 by enema), and in the third fifteen weeks after a barium enema.

The author believes that the paucity of reports of appendicitis following retention of barium in the appendix may be due to failure of recognition of this as the cause, x-ray examination being infrequently carried out prior to appendectomy. He concludes that any patient whose appendix retains barium longer than one week after an examination should be advised of the possibility of an abnormal state of that organ and an increased chance for subsequent development of appendicitis. Consideration of elective appendectomy is suggested in those instances in which barium is retained longer than one month.

Seven roentgenograms; 1 table.

R. P. STORRS, M.D.
Los Angeles, Calif.

Pancreatography in the Diagnosis of Chronic Relapsing Pancreatitis. A. V. Pollock. Surg., Gynec. & Obst. **107:** 765–770, December 1958. (University of Leeds, Leeds, England)

The author cites the work of Doubilet, Poppel, and Mulholland (Radiology **64:** 325, 1955) on transduodenal pancreatography. These workers injected 70 per cent Urokon or 70 per cent Diodone into the pancreatic duct, obtaining opacification of the gland substance in acute pancreatitis and dilatation of the main duct in chronic pancreatitis. They concluded that the procedure was no more difficult than operative cholangiography and was without danger.

Using a transduodenal incision and cannulating the pancreatic duct with a polyethylene tube, the author carried out the procedure on 33 cadavers, in order to establish the normal appearance of the duct, and later on 11 patients undergoing transduodenal division of the sphincter of Oddi, mostly for recurrent pancreatitis. He used 2 c.c. of 35 per cent Diodone.

Considerable variation in the caliber and contour of

the main pancreatic duct was encountered in the absence of a history of pancreatitis; dilatation of the duct, found at autopsy, was often considerable in older subjects and in the presence of gallstones, without pancreatitis.

The findings in the patients with pancreatitis were not significantly different from those in the normal cadaver series. Opacification of the substance of the gland was obtained in 1 case with a history of acute pancreatitis. No strictures of the pancreatic duct were demonstrated.

Of the 11 patients studied, 1 died following disruption of the duodenal suture line; 8 had uneventful recoveries (of these, 2 had markedly elevated serum amylase levels following the study); in 2 frank pancreatitis developed, and 1 of these died.

The author concludes that the procedure is of negligible diagnostic value and is not devoid of serious danger.

Four roentgenograms. FRED J. MUNSON, M.D.
University of Pennsylvania

Diagnosis of Tumors of the Pancreas with the Aid of Pneumoretroperitoneal Pancreatography and Splenoportography. Robert D. Moseley, Jr. Am. J. Roentgenol. **80:** 967–977, December 1958. (950 E. 59th St., Chicago, Ill.)

Pneumoretroperitoneal pancreatography was performed in 25 patients to investigate a possible pancreatic neoplasm. After Duografin had been administered intravenously to visualize the biliary and urinary tracts, carbon dioxide was injected retroperitoneally *via* the presacral route. Thirty cubic centimeters of Renografin was then given orally to opacify the stomach and duodenum.

A pancreatic mass was demonstrated in 17 of the 25 cases, all of which were confirmed at surgery or autopsy. Duodenal cytology and pancreatic secretion tests were postive in all except 1 of these cases. Routine upper gastrointestinal series revealed abnormalities in the second portion of the duodenum in all 17 patients but the pancreas was considered to be normal in 8 of these.

Lesions in all parts of the pancreas were demonstrated by this method. An important part of the examination was lateral laminagraphy, which made lesions in the body and tail of the pancreas more easily visible.

In 7 of the 17 cases with demonstrable pancreatic enlargement, splenoportograms were obtained. Six of these disclosed involvement of the splenic vein, indicating such extensive invasiveness that radical surgery was not indicated. In the 1 case with a normal splenoportogram, radical pancreatico-duodenectomy was technically simple. The author stresses the importance of preoperative splenoportography to help in planning or excluding radical surgery.

Twenty-nine roentgenograms.

CAPT. H. GOULD, M.C.
St. Vincent's Hospital, New York

Cystic Fibrosis of the Pancreas: Intestinal Absorption of Fat and Fatty Acid Labeled with I^{131}. Keith Reemtsma, Paul A. di Sant'Agnese, James R. Malm, and Harold G. Barker. Pediatrics **22:** 525–532, September 1958. (H. G. B., 630 West 168th St., New York 32, N. Y.)

Comparative studies of intestinal absorption utilizing test meals of I^{131}-labeled neutral fat and fatty acid, administered on different occasions to the same person, were performed in 10 patients with cystic fibrosis of the pancreas and in 13 control children. The results are compared with those previously obtained and reported in various groups of adults. Two of the patients with cystic fibrosis had normal tryptic activity in the duodenal aspirate; the experimental data in these 2 patients are presented, but no conclusions are drawn therefrom.

All of the 8 patients with cystic fibrosis and pancreatic achylia showed impairment of intestinal absorption of neutral fat, and to a lesser degree, of fatty acid. While the former result was expected, the impaired absorption of fatty acids was not, and is at variance with results in adults with acquired pancreatic deficiency. The hypothesis is advanced that an intestinal factor other than lack of pancreatic enzymes may be partially responsible for the defect in absorption in cystic fibrosis of the pancreas.

Two figures; 4 tables.

Necropsy Evaluation of the Gas Contrast Roentgen Visualization of Liver and Spleen. Samuel Zelman. Am. J. M. Sc. **236:** 747–754, December 1958. (VA Hospital, Topeka, Kans.)

The author describes a roentgen technic for estimation of liver and spleen size, which has been used at his hospital (VA Hospital, Topeka, Kans.) since 1948. To evaluate the accuracy of the procedure, the actual weight of these organs in 20 patients was determined at autopsy.

The examination consists of outlining the stomach and colon with gas (the former with Seidlitz powder ingestion and the latter with air insufflation) and obtaining roentgenograms in the upright frontal position for the liver and left anterior (30°) oblique for the spleen, at 40 inches distance. From these roentgenograms the length and width of the organs are measured. In the spleen the longest and shortest diameters at right angles are used. The liver length is taken from the highest point of the diaphragm to the right lower edge, while the width is measured from the costophrenic angle to the midpoint of the lower border. Measurements of the heart were also taken for comparison purposes.

The product of the two roentgen diameters was used in the case of each organ (liver, spleen, and heart) for correlation with necropsy weights (interim between examination and autopsy less than three months). The coefficient of correlation was found to be as follows: for 19 livers 0.509; for 20 spleens, 0.718; for 20 hearts, 0.623.

Though subject to the play of a number of variables discussed in the report, which tend to lower correlation, the coefficient obtained for the liver and spleen proved comparable to that between the roentgen measurement of the heart and its weight at necropsy. It is concluded, therefore, that roentgen representations of the liver and spleen obtained with the gas-contrast method warrant the degree of clinical confidence accorded roentgen representation of the heart.

Three roentgenograms; 3 graphs; 3 tables.

J. S. ARAJ, M.D.
Toledo, Ohio

Venographic and Scintillographic Demonstration of Liver Metastases. C. G. Helander, L. Jonsson, L.-G. Larsson, Å. Lindbom, and P. Ödman. Acta radiol. **50:** 533–542, December 1958. (Karolinska Sjukhuset, Stockholm, Sweden)

It is possible to study the liver by catheterization of

the hepatic veins and injection of a contrast medium. It can also be studied by scintillographic examination following administration of certain radioactive isotopes which it takes up selectively. The authors of this paper compare the two methods with reference to their value in demonstrating liver metastases, and report on 25 cases examined by one or both technics.

On the venograms metastases were indicated by rounded indentations bulging into the lumen of the larger branches of the hepatic veins, with curved displacements of the smaller branches. Contrast defects in the liver parenchyma were also suggestive of disease. Five of 6 patients with clinically known liver metastases showed definite changes. In 1 case metastases were proved which were previously suspected but not clinically verified.

Scintillograms revealed uptake of colloidal Au^{198} by the liver but not by tumor tissue, and were abnormal in all cases with clinically known metastases. In 1 other case the scintillogram was negative, although venography disclosed multiple metastases.

The scintillographic method is probably the more suitable for routine employment, since it is much simpler. With the venographic method in some cases only a limited part of the liver can be examined. On the scintillograms small metastases may be concealed by overlapping normal liver tissue. Use of both methods is recommended in doubtful cases.

Seven roentgenograms; 6 scintillograms.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Biliary Tract Roentgenography in Lateral Decubitus Position. John H. Walker. Am. J. Roentgenol. **80:** 945–949, December 1958. (Mason Clinic, Seattle 1, Wash.)

The right lateral decubitus position is recommended for routine oral cholecystography. The advantages stated are as follows: 1. Fewer exposures are required than by other methods, an average of 2.2 films per patient being sufficient. 2. The liver offers a homogeneous background free of gas and fecal shadows. 3. When small stones or sand are present "layering" is demonstrated. This also serves to help differentiate stones from intraluminal tumors of the gallbladder. (4) When nonvisualization is a result of gastric outlet obstruction, the contrast material is seen in the pyloric antrum in the dependent position, indicating that failure of visualization may not be on the basis of biliary tract disease. 5. Re-examinations are reduced to a minimum.

The author's technic avoids placing the patient on a hospital cart by utilizing a small portable movable grid held in place by a special frame which can be attached to the radiographic table. Two films are routinely obtained, one before ingestion of a cholagogue and one afterward. In certain unusual cases an upright compression film is found to be necessary to complete the examination.

Eight roentgenograms; 3 photographs.

MAJ. MARTIN A. THOMAS, M.C.
MacDill AFB, Tampa, Fla.

Emptying of the Human Gallbladder Under the Stimulus of Cholecystokinin. Paul Edholm. Acta radiol. **50:** 521–532, December 1958. (Karolinska Institutet, Stockholm, Sweden)

Cholecystokinin, derived from the duodenal mucosa, if injected intravenously causes contraction of the gallbladder. Clinical trials of the material in cholecystography are reported in this paper.

One hundred and two patients with symptoms suggestive of biliary disease were examined. In most cases Telepaque was the contrast medium used. Following preliminary conventional roentgenography of the opacified gallbladder, the cholecystokinin was given by intravenous drip, and numerous films were made during its administration.

Films obtained prior to administration of cholecystokinin revealed contrast filling of ducts in a number of cases, and distribution of the medium depended on the patient's position. During emptying induced by cholecystokinin the filling of the ducts varied, depending upon the concentrating power of the gallbladder. Among the 102 cases in the present series, only 3 failed to show filling of the common duct. The hepatic duct failed to fill in 25 cases (42 per cent) examined with the patient in horizontal position and in 11 (26 per cent) examined with the head tilted downward. It is therefore suggested that the hepatic duct fills more frequently in the latter position and that demonstration of this duct is no evidence of biliary disease.

In the patients in whom the ducts were outlined, the visualization was generally better than in intravenous cholangiography. The ducts did not appear to change caliber significantly during emptying. Almost half the patients experienced biliary-type discomfort in varying degrees during emptying of the gallbladder.

Twenty-two roentgenograms; 5 diagrams.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Radiologic Diagnosis of Hypertonia of the Sphincter of Oddi, and of Cystic Duct Disease. Lidio G. Mosca. Radiología **9:** 9–13, December 1958. (In Spanish) (Universidad de Antioquia, Medellín, Colombia)

This article discusses rather fully the radiographic diagnosis of cystic duct disease and of hypertonicity of the sphincter of Oddi by means of oral cholecystography.

The author believes that the hepatic ducts have "sphincter zones" at their bases; which, though anatomically undefined, are functionally real. These serve, in his view, to prevent upward or retrograde reflux of contents of the common bile duct into the liver.

In cholecystography, fatty meal administration should produce simultaneous contraction of the gallbladder and relaxation of the sphincter of Oddi, with emptying of contrast medium into the duodenum. If the sphincter of Oddi is hypertonic or hypertrophied, contraction will tend to continue, until eventually the resistance to retrograde flow will be overcome, and reflux of medium into the liver will occur. When this is seen, therefore, hypertonicity of the sphincter of Oddi can be presumed to be present. If oral cholecystography reveals opacity of the duct system as high as the liver, the author feels that a diagnosis of sphincter hypertrophy is justified.

If such hypertonicity is indicated by an examination which reveals apparently normal gallbladder function otherwise, surgery should be undertaken with caution. Cholecystectomy should by all means be accompanied by correction of the sphincter stenosis to avoid the post-cholecystectomy syndrome.

In gallbladders with thick walls, sphincter hypertrophy is common, due to elevation of intraductal pres-

sures from loss of compensatory function in the gallbladder.

In the presence of gallbladder disease the cystic duct is often narrowed somewhat. This may interfere with free emptying after a fatty meal. Functional spasm and congenital obstacles of various sorts are other causes of blockage of the cystic duct. In these cases the gallbladder may appear large and atonic. At times it may fill well but empty poorly on contraction.

The radiographic diagnosis of cystic duct disease depends on two signs: (1) change in the gallbladder on contraction to a round or ovoid shape with little loss of volume; (2) failure of opacification of the cystic and common ducts after contraction of the contrast-filled gallbladder.

The author feels that, although these signs have been discounted by some observers, proper technics will prove their validity. A few supporting statistics are presented from other workers.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Roentgenographic Study of Congenital Choledochal Cysts. Pre- and Postoperative Analysis of Five Cases. Edwin J. Liebner. Am. J. Roentgenol. **80:** 950–960, December 1958. (840 S. Wood St., Chicago, Ill.)

Congenital cysts of the common bile duct are relatively uncommon but are being recognized more frequently since the development of intravenous chloangiography. A clinical triad consisting of abdominal pain, palpable tumor mass, and jaundice is demonstrable in approximately 60 per cent of the recorded cases. Females predominate about four to one. Operative treatment is indicated, the operation currently favored being choledochoduodenostomy.

Five cases seen by the author are reported in moderate detail and the pertinent clinical findings are given in a table. All of the patients were females; all but one were children.

Salient radiologic findings are also presented in tabular form. Plain radiographs ordinarily show a soft-tissue mass in the right upper quadrant, overlying the liver and separate from the kidney. If the cyst is large, it will displace the colon, duodenum, or stomach. Oral cholecystography usually fails to demonstrate the gallbladder. Barium studies of the upper gastrointestinal tract will show anterior and inferior displacement of the duodenal loop, usually with displacement to the left or deep indentation. This roentgenologic triad—soft-tissue mass, duodenal impression, and nonvisualization of the gallbladder—along with any two of the clinical signs mentioned above will permit a preoperative diagnosis. This may be confirmed by intravenous cholecystography provided the serum bilirubin levels permit. If the patient is examined when the serum bilirubin levels are within the normal range, the cyst will be filled as a dilated, faintly opacified structure. Dilatation of the hepatic radicals is usually associated. After operation, plain films may show remnants of the cyst with air and/or fluid levels in the cyst and biliary ducts. Intravenous cholecystography may show the status of the lesion and aid in assessing postoperative symptoms. Occasionally introduction of contrast material in the cyst through an aspiration needle or through an indwelling post-surgical tube has given helpful information.

It is theorized that congenital choledochal cysts may be similar in etiology to megacolon, megaureter, and megaesophagus. Megacholedochus may be primarily a difficulty of neuromuscular function or anatomy.

Fifteen roentgenograms; 2 tables.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

HERNIA

Hiatal Hernia: Its Diagnosis and Clinical Significance. Ernst Hafter. Am. J. Digest. Dis. **3:** 901–915, December 1958. (36 Toedistrasse, Zurich, Switzerland)

This paper is based upon 300 cases of hiatus hernia found in 2,400 consecutive gastrointestinal examinations of private patients. The radiologic technic for demonstrating the hernia was generally similar to the methods described by others. The prone position on the Bucky table with epigastric compression by a balloon or firm pillow has proved the most reliable method in the author's experience, giving 95 per cent positive results. It is felt that if the communication between the esophagus and stomach is not interrupted by deep inspiration, as observed at fluoroscopy following a barium swallow, then the esophageal hiatus is incompetent and the appearance of a hernia may be expected during the next expiration.

Findings are presented in tabular form, with subdivision as to size of hernia, age distribution, and symptoms and signs. The overall incidence of hiatus hernia in unselected patients is estimated by the author to be between 8 and 10 per cent, though the incidence in his own series is higher (12.5 per cent). Only 1 per cent of the cases in this series were paraesophageal; all the others were examples of esophagogastric hernia or "short esophagus."

Only about 4 per cent of patients with demonstrable hiatus hernias seem to be completely asymptomatic. Nearly one-tenth of the total had hypochromic anemia. Although more than half of the series showed coexistent diseases, it was not felt that these were related to the hiatus hernia.

It is the author's feeling that surgical treatment should be reserved for cases with complications and/or intractable symptoms. Only 8 per cent of his patients had been surgically treated. Conservative therapy is sufficient for relief of symptoms in most instances.

Thirteen roentgenograms; 3 tables.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Use of Prone-Pressure Device for Visualizing Hiatus Hernia. Richard H. Marshak and Arnold Gerson. Am. J. Digest. Dis. **3:** 857–860, November 1958. (R. H. M., 1075 Park Ave., New York 28, N. Y.)

The authors report a case to illustrate the value of a prone-pressure device (Wolf and Guglielmo: J. Mt. Sinai Hosp. **23:** 738, 1956) for visualizing hiatus hernia. Use of this device increases intra-abdominal pressure, without increasing intrathoracic pressure, and does not require the active participation of the patient.

The chief complaint in the case reported was severe "heartburn" of many years duration. Numerous examinations, including four gastrointestinal series, during a three-year period, showed no hiatus hernia or ulcer niche. Because of especially severe symptoms, the patient was referred for another gastrointestinal series. This was performed utilizing the prone right anterior oblique and Trendelenburg positions and the Valsalva

and Müller tests; a very small hiatus hernia was disclosed. The examination was repeated, with the prone-pressure abdominal pad. A moderately large hiatus hernia, with free esophageal regurgitation, was clearly and easily demonstrated.

Four roentgenograms.

THE MUSCULOSKELETAL SYSTEM

The Rate of Growth in Length of the Long Bones, in Certain Pathological Conditions. (An X-ray Study.) L. Drey. Ann. paediat. **191:** 355–363, December 1958. (Municipal Hospital Hadassah, Tel Aviv, Israel)

Maresh (Am. J. Dis. Child. **66:** 227, 1943. Abst. in Radiology **43:** 203, 1944) published a table of bone length measurements calculated at six-month intervals, the measurements being from one epiphyseal line to the other. The present author suggests a method for determining expected rates of bone growth for shorter and longer intervals. This consists in construction of a "differential angle diagram": the horizontal axis represents the time of observation in months and the vertical axis the difference in length of bone, measured in millimeters. From these two figures an "angle of bone growth" can be calculated. Illustrative examples for normal bone growth are presented and explained.

This method of determination of rate of bone growth is then applied to various disease entities involving bone and cartilage, in an attempt to demonstrate diagnostic differences. Disproportional bone growth is shown in achondroplasic disease, for example, as a disturbance in the differential angle diagram: the proximal parts of the extremities are growing more slowly than the distal ones. In chondroectodermal dysplasia, the reverse is true, with the distal portions of the bones growing more rapidly than the proximal. These differences can be appreciated by utilization of the author's differential diagram.

Six diagrams.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

The Retarding Effect of Protracted Undernutrition on the Appearance of the Postnatal Ossification Centers in the Hand and Wrist. Samuel Dreizen, Richard M. Snodgrasse, Hamilton Webb-Peploe, and Tom D. Spies. Human Biol. **30:** 253–264, December 1958. (Department of Nutrition and Metabolism, Northwestern University, Chicago, Ill.)

Five hundred and forty-one white, native-born Alabama children of similar ethnic background were arbitrarily selected from the growth study group of a nutrition clinic. Serial sequential roentgenograms of the left hand and wrist covering the period of growth were available for each of the 301 boys and 240 girls. Adequate histories of each of these children were obtained. All of them presented evidence sufficient for a clinical diagnosis of undernutrition.

Analysis of the data—in relation to the age-standards in the Greulich-Pyle *Atlas*—shows that the effects of undernutrition include (1) a signal failure to attain expected stature, (2) a high degree of asymmetry in the maturation of the skeleton of the hand, (3) a lagging rate of skeletal development, (4) a considerable frequency and variety of anomalies in the bones of the hand, (5) persistence of radiopaque transverse lines in the distal end of the shaft of the radius, and (6) delayed fusion of the epiphyses of the hand, distal radius, and ulna.

The mean time of appearance for each of the 31 ossification centers studied was delayed in the undernourished children of either sex. Some or all of the assessable centers were delayed in 504 (91.3 per cent) of the 541 children. Delay was more pronounced in the carpals than in the metacarpal and phalangeal epiphyses. In both sexes, the delay in onset of ossification in the epiphysis of the distal ulna greatly exceeded that of the distal epiphysis of the radius. Quantitatively, in boys the average delay ranged from 1.2 months for the adductor sesamoid of the thumb to 28.9 months for the greater multangular; and in girls, from 1.8 months for the proximal phalanx of the third digit to 18.3 months for the greater multangular.

Four roentgenograms: 3 tables.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

The Arteriographic Picture of Metastatic Bone Disease. Robert Schobinger. Cancer **11:** 1264–1268, November-December 1958.

This report is based upon arteriograms which were obtained by the writer in patients with bone metastases from neoplasms of the prostate, breast, kidney, lung, and thyroid, and from 1 case of neuroblastoma.

The osteolytic lesions showed varying vascular patterns, depending mainly on size and location. The osteoblastic lesions were found to be relatively avascular and usually had no characteristic radiographic appearance.

In some cases arteriography outlined the entire contour of the metastasis. Sometimes areas normally avascular showed increased numbers of arteries. These often were tortuous, converging toward the lesion. Others were of increased caliber. Veins which were increased in size or numbers were noted in a few instances, especially in regions where the bony cortex was eroded. No arteriovenous fistulas were observed, although they are generally held to be one of the characteristic features of malignant neoplasm.

Inasmuch as conventional angiograms do not show the vessels in normal bone, the presence of disease is suggested whenever the circulation is demonstrable arteriographically.

Nine roentgenograms.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Cleidocranial Dysostosis. Report of Two Cases with Special Characteristics. Johannes Thoms. Acta radiol. **50:** 514–520, December 1958. (Aarhus Kommunehospital, Denmark)

Cleidocranial dysostosis, due to deficient or delayed development of bones preformed in connective tissue or cartilage, consists in defective development or absence of the clavicles and ossification defects over the cranium. Other widely varying skeletal anomalies and abnormalities have been reported in association with the condition.

The author here reports 2 cases in which widespread osteosclerosis of bony structures including the skull was observed in addition to the more usual abnormal findings. One of the patients and 2 of his siblings had increased bone fragility and an increased tendency to fractures. Both patients had prominent coxa valga instead of coxa vara, which is more common in this condition.

Other x-ray abnormalities which may sometimes be

seen and which were present in these cases are: hypoplastic maxilla, wide mandibular angle, scapular winging, hypoplastic and tapered terminal phalanges of the fingers, and persistent central vascular grooves in the vertebral bodies anteriorly.

Nothing in the radiographic or laboratory findings would account for the osteosclerosis, and it was felt to be due to the same unknown factor which causes the cleidocranial dysostosis.

Six roentgenograms.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Undulant Fever Spondylitis. F. Zammit. Brit. J. Radiol. **31:** 683–690, December 1958. (St. Luke's Hospital, Malta)

Undulant fever, caused by *Brucella melitensis*, is endemic in Malta, being most common in children under ten years of age. The signs and symptoms of spondylitis manifest themselves during the period of convalescence in the typical case. The earliest symptom is pain localized to the affected region of the spine. It is usually progressive and is made worse by motion. Cord compression occurred in 8 of a series of 62 cases. The highest incidence of spondylitis was in the fifth and sixth decades with 54 of the 62 cases occurring between the ages of thirty and seventy years. Only one-third of the patients were females. The regional distribution was as follows: cervical 5; dorsal 16; combined dorsal and lumbar 4; lumbar 37. The fourth lumbar vertebra is most commonly involved.

Radiological changes include lesions of the vertebral bodies, changes in the disk space, proliferative marginal reactions, and changes in the intervertebral joints.

Lesions of the vertebral bodies may be marginal or central. Marginal lesions usually begin as an ill-defined erosion or a small area of rarefaction at the anterior and superior margin of the vertebra. Such areas may be limited by the development of a sclerotic rim or may progress. Progression is characterized by increased density and irregularity of the trabecular pattern in the vicinity of the involved angle of the vertebral body. Erosion of the anterior edge of the adjacent body may develop. Bone destruction is not marked radiologically.

Rarely, foci of destruction appear in the spongy part in the vicinity of the disk space, without any evidence of a marginal lesion. Some collapse of the vertebra may occur.

The disk spaces are generally narrowed. Proliferative marginal reactions are common, are very pronounced, and develop in a short time. Erosion of the intervertebral joints was not demonstrated.

To be considered in the differential diagnosis are Pott's disease, staphylococcal osteomyelitis, actinomycosis, Scheuermann's disease, and osteoarthritis. Treatment is by antibiotics and bed rest.

Ten roentgenograms; 3 tables.

CHARLES H. HELMEN, M.D.
Indiana University Medical Center

Intrapartum Lateral X-ray in the Conduct of Dystocic Labors. Leonard M. Roberts, Jack J. Squire, Alan F. Guttmacher, and Richard Marshak. Am. J. Obst. & Gynec. **76:** 1306–1313, December 1958. (Mount Sinai Hospital, New York, N. Y.)

Fifty cases of dystocia in which a lateral roentgenogram was obtained during labor were analyzed. One lateral view was taken during labor in 39 cases, two lateral views in 7, and three in 4. Most of the patients had had pelvimetry during the antepartum period for clinically suspected pelvic contraction of some degree.

These studies were done on the labor floor, the films being taken with the patient standing or reclining. Target-film distances of 72 or 54 inches were used, and measurements were taken from a calibrated centimeter ruler.

This procedure furnished valuable information as to the cause of dystocia and the plane of obstruction. In 11 cases it provided a graphic guide to progress or lack of progress of labor. In 24 cases Pitocin was used to stimulate labor, thus avoiding undue prolongation.

Seven roentgenograms; 2 tables.

ROBERT L. EGAN, M.D.
University of Texas, Houston

Symposium: Myelography in the Diagnosis of Diseases of the Spinal Canal. Part 1: The Clinical Indications for Myelographic Examination in Diseases of the Spinal Cord and the Spinal Canal. Gerald Moss. Proc. Coll. of Radiologists of Australasia **2:** 24–26, September 1958.

This paper is concerned with the indications for myelography, particularly in developing paraplegia. The nonacute case is first considered. The combination of a complete or partial spinal block and increased protein in the cerebrospinal fluid clearly calls for myelography. Signs of block may, however, be absent, in which event increased protein together with clinical evidence is thought to be an indication. Occasionally, a partial spinal block, with normal protein level may occur. Again, it is not uncommon, as in cord pressure from cervical spondylosis, for there to be no sign of block and no increase in protein. Here, clinical evidence should be the deciding factor.

There are cases in which neurological signs, especially if associated with plain-film radiological signs, seem clearly to indicate the level of the lesion and there is evidence of spinal block as well. Some would say that in these circumstances myelography is not indicated and the patient should not be subjected to the procedure, but, while there are cases in which this attitude is justified, there may be reasons for determining the upper or lower level of the lesion and only myelography can give this information. Occasionally, a slowly developing paralysis, following lumbar puncture, becomes more progressive, and myelography with a view to immediate operation becomes urgent.

In the presence of acutely developing paralysis, differentiation of certain lesions from transverse myelitis may be difficult. It may well be that in clear-cut cases of transverse myelitis myelography is not justified; however, such conditions as sudden edema or hemorrhage from an intramedullary tumor or vascular anomaly of the cord may produce the same symptomatology. Myelography in these conditions is indicated. A series is cited in which 31 patients thought to have transverse myelitis were autopsied, and myelomalacia due to vascular anomaly was found in 9. Other conditions presenting an urgent indication for prompt surgery, preceded by myelography, are acute spinal abscess and spontaneous epidural spinal hemorrhage.

In cases of metastatic malignant disease with collapse of vertebrae and sudden paraplegia or extradural metastases, myelography may be indicated to determine the

level of block if the clinical signs are not adequate for management.

In cervical spondylosis, cord and root damage can be usually diagnosed by the clinician. The author feels, however, that if operation is proposed, myelography is indicated in all cases. It may not be necessary if conservative treatment is planned.

The clinical features of cervical cord lesions and their importance are strongly stressed. The author feels that myelography is not indicated in all cases of lumbar disk herniation, when operation is contemplated, since the clinical diagnosis is accurate and the results good in properly selected cases.

DAVID H. NEWBERN, M.D.
Bowman Gray School of Medicine

Symposium: Myelography in the Diagnosis of Diseases of the Spinal Canal. Part 2: Diseases of the Spinal Cord and Its Covering with Special Reference to the Application of Myelography. M. D. Begley. Proc. Coll. of Radiologists of Australasia **2:** 27–32, September 1958.

The three main types of disease to which myelography is applied are (1) spinal cord tumors; (2) dermoids, vascular anomalies, and syringomyelia; (3) spinal trauma and disk abnormalities.

Extradural lesions cause tapering of the opaque column, widening of the gap between the theca and the vertebra, and negligible displacement of the cord. Intradural extramedullary lesions displace the cord away from the side of the lesion and open up the subarachnoid space. These lesions are usually meningiomas or neurofibromas. Intramedullary tumors, vascular malformations, and syringomyelic cavities expand the cord over several sequents resulting in a fusiform appearance. A symmetrical concave filling defect results if obstruction is complete.

Gas or positive contrast myelography is of value in the diagnosis of diastematomyelia, in which the contrast material may be seen dividing around the split cord. Fusiform enlargement of the spinal canal with normal pedicles and the presence of a spina bifida are radiographic features which aid in diagnosis. The demonstration of a midline spur is said to be pathognomonic of the condition.

The author points out the value of both gas and iodized oil myelography in the identification of the Arnold-Chiari malformation. Cerebellar herniation into the spinal canal is clearly outlined by these methods.

Avulsion of roots of the brachial plexus can be demonstrated by iodized oil myelography. A sac is visualized in positive cases, producing, in effect, a traumatic meningocele.

Diffuse meningeal neoplasia manifests itself usually as a neurological disorder with protean physical signs, often as a subacute or chronic meningoencephalopathy. Myelography may be an aid in making the diagnosis.

Ten roentgenograms.

DAVID L. ROBINSON, M.D.
Bowman Gray School of Medicine

Symposium: Myelography in the Diagnosis of Diseases of the Spinal Canal. Part 3: Prolapse of the Intervertebral Discs and Vascular Disease of the Spinal Canal. A. A. Merritt. Proc. Coll. of Radiologists of Australasia **2:** 33–39, September 1958.

The author reviews 85 cases submitted to myelography: 47 for low-back pain and 38 for other reasons.

In 23 cases explored for disk herniation, the myelographic diagnosis was confirmed in 19. The myelographic findings indicative of this condition are: (1) hindrance to the flow of the medium, without obstruction unless the protrusion is large; (2) filling defect in the opaque column; (3) failure of the nerve root to fill; (4) displacement of the nerve sheath medially or laterally; (5) edema of the nerve root proximal to the extruded disk, shown by a linear translucency in the contrast column. The complication of ligamentum flavum is discussed and a case is presented.

Myelography is a reasonably accurate method of demonstrating a protruded disk, but, since false negative results may be obtained, clinical evaluation must predominate over negative myelography. It is felt, however, that myelography serves to forewarn the surgeon as to the presence of a bilateral disk protrusion or multiple disk lesions.

Hematomas of the spinal canal are rare and can occur extradurally, subdurally, and in the subarachnoid space. They may extend over two or three segments. Clinically there is a sudden onset of severe pain at the level of the lesion, generally after straining, with rapidly progressing cord signs. On myelography a block may be found or there may be a splitting or streaking of the opaque column.

The diagnosis of vascular lesions of the cord is felt to be a clinical problem, with myelography as a confirmatory procedure; negative radiologic findings do not deny the clinical diagnosis. If a vascular malformation is found, unnecessary surgery may be avoided.

Five roentgenograms; 3 tables.

C. F. TAYLOR, M.D.
Bowman Gray School of Medicine

Symposium: Myelography in the Diagnosis of Diseases of the Spinal Canal. Part 4: Discussion. C. W. D. Lewis. Proc. Coll. of Radiologists of Australasia **2:** 39–41, September 1958.

In a Discussion concluding the Symposium on myelography represented by the three preceding abstracts, Lewis calls attention to thickening of the ligamenta flava. He believes it to be a regular accompaniment of intervertebral disk protrusion. Not only this, but there is sometimes adherence to the underlying dura, which of itself may be a source of pain.

Brief mention is made of discography, which may be justified when myelography is inconclusive, of the toxicity of contrast agents introduced into the spinal canal, and various other phases of myelography.

JOSEPH E. WHITLEY, M.D.
Bowman Gray School of Medicine

A Little Known Radiological Sign of the Vertebral Column in Ankylosing Spondylitis (Strümpell-Marie-Bechterew's Disease). K. Maier. Fortschr. a. d. Geb. d. Röntgenstrahlen **89:** 331–338, September 1958. (In German) (Orthopädische Universitätsklinik "Friedrichsheim," Frankfurt/Main, Germany)

The most common indications of ankylosing spondylitis are changes in the sacroiliac joints, osteoporosis of the vertebral bodies, and synostosis of the facet joints, of the disks, and of the intervertebral ligaments. Ordinarily the disease is diagnosed only after ankylosis is considerable. The author calls attention to a sign which, while not constantly present, is often one of the earliest, *i.e.*, the "squaring" or "box-like" aspect of the vertebral bodies, best seen in the lateral view. The normally rounded upper and lower anterior edges be-

come pointed and the concave anterior contour of the body is straightened, giving a "square" appearance, noticeable mostly in the upper lumbar and cervical regions. It is assumed that nonspecific inflammatory processes are causing a resorption of bone substance in the upper and lower edges, leaving the portion between intact.

Of 53 proved cases of ankylosing spondylitis, all showed changes in the sacroiliac joints: "syndesmophytis" (calcifications in the intervertebral ligaments) in 50, "squaring" of the vertebral bodies in 49, calcification of the facet joints in 42, and osteoporosis of the vertebral bodies in 30. Sacroiliac changes were always observed first, but "squaring" often occurred before calcification of the ligaments, and in doubtful cases may point the way to a correct diagnosis.

In the late stages of the disease, when the calcification of the anterior ligaments has become complete, the "squaring" of the vertebral bodies disappears and the undulating appearance of the bamboo spine again becomes evident.

Eleven roentgenograms.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

Osteomyelitis of the Femoral Neck. G. Brantschen. Radiol. clin. **27:** 351–356, November 1958. (In French) (Institut universitaire médicale de Lausanne, Switzerland)

Two cases of osteomyelitis of the femoral neck are reported, in each of which the roentgen picture had apparently been modified by previous administration of antibiotics.

One patient, a 48-year-old man with clinical symptoms of disease of the hip for four months, had been treated with several antirheumatic drugs as well as antibiotics. Roentgenographic studies showed a small cavity in the neck of the right femur. Tomograms revealed two small central opacities which were thought to represent sequestra. The area of involvement appeared relatively well demarcated. Biopsy revealed signs of nonspecific osteomyelitis. No organism was demonstrated on cultures.

The second case was that of a child of nine years with symptoms in the right hip four months after a siege of bronchopneumonia. Roentgen studies showed a relatively well demarcated radiolucent region in the femoral neck just distal to the epiphyseal line, with one small opacity within the radiolucent area. This was considered to be a sequestrum. Curettage and study of the bone fragments revealed a nonspecific type of osteomyelitis.

Five roentgenograms.

CHARLES M. NICE, JR., M.D., Ph.D.
Tulane University

Radiologic Study of Physiologic Knock Knee in Childhood. D. W. MacEwan and J. S. Dunbar. J. Canad. A. Radiologists **9:** 59–63, December 1958. (Montreal Children's Hospital, Montreal, Que., Canada)

Knock knee (genu valgum) is defined as any malleolar separation when the medial surfaces of the knee just touch with the lower extremities in the anatomic position, *i.e.*, with the patella and the great toe pointing directly anteriorly. It may be either physiologic or pathologic.

Physiologic knock knee is rare before the age of two and is most marked from three to three and a half years. Malleolar separation up to 4 or 5 inches is seen, and even in such cases straightening occurs spontaneously. In some instances there is said to be a familial tendency. Pathologic knock knee can be excluded on the basis of the clinical and roentgen findings.

Seven cases showing the typical changes of physiologic knock knee are reported. In each child the first roentgen and clinical examination showed genu valgum, always bilateral, more marked on one side than on the other. The final examination in each case revealed a return to normal. Four of the group received no therapy whatever; the others had small wedges or lifts attached to the shoes.

Fifteen roentgenograms; 1 table.

R. S. ORMOND, M.D.
The Henry Ford Hospital

Paget's Disease of the Patella. Lawrence Gordon. J. Bone & Joint Surg. **40-A:** 1423–1425, December 1958. (Stanford University Hospitals, San Francisco 15, Calif.)

The author presents what he believes to be the first recorded case of Paget's disease localized to the patella. In 1943, the patient, while riding on a bus, struck her left knee on a suitcase; she immediately felt a severe, sharp pain, which for five days prevented her from walking. Roentgen examination showed Paget's disease of the patella, without evidence of fracture. Immobilization of the knee in a cast relieved the symptoms, and the patient remained in good health until May 1955, when she twisted the left knee. Pain increased gradually over the following eight months, and roentgenograms demonstrated progress of the disease process. Patellectomy was carried out in February 1956, and the diagnosis of Paget's disease was confirmed histologically. No other pathological process was noted in the knee during the operation, and a skeletal survey again disclosed no evidence of other bone involvement.

Three roentgenograms; 1 photomicrograph.

Unusual Manifestations in a Case of Relapsing, Nodular, Febrile Panniculitis (Weber-Christian Disease). Leonard M. Goldberg and Leonard W. Ritzmann. Am. J. Med. **25:** 788–795, November 1958. (VA Hospital, Portland, Ore.)

A case of relapsing, nodular, febrile panniculitis (Weber-Christian disease) with a number of unusual features is reported. Among these was extensive bone involvement. Serial roentgenograms demonstrated the evolution of a typical protrusio acetabuli. It is assumed that the trauma of an accidental fall in 1948 produced inflammatory necrosis in the synovial fat (haversian glands) of the acetabulum with subsequent destruction of the acetabular floor. Early roentgen studies of the knee demonstrated definite demineralization of the distal end of the femur and proximal tibia. Serial films showed a return of calcium, but in heavy, coarse, irregular striations, possibly the result of recalcification in areas underlying the inflammatory process in the synovial fat, and differing from the recalcification following demineralization of bone by disuse. While surgical biopsy of one of the involved bones was desirable, it was thought inadvisable because of a history of prolonged drainage following the original hip trauma.

Eleven roentgenograms; 2 photomicrographs: 1 electrocardiogram.

GYNECOLOGY AND OBSTETRICS

The Accuracy of the Radiological Estimation of Foetal Age. P. W. Verco. Proc. Coll. of Radiologists of Australasia **2**: 42–45, September 1958.

An attempt was made by the author to determine the accuracy of the radiologic estimation of fetal age. He apparently used as his main criterion the visibility and development of the proximal tibial epiphysis, which he considered to appear about the thirty-eighth week of gestation. His study is based upon 447 consecutive single pregnancies, in which the calculated date of delivery was compared to the radiologist's predicted natal day.

There was absolute agreement of the two methods in 22 per cent of the cases. The author, however, admits that his material is highly selected, that it is uncorrected, and that three-fourths of his patients were examined at or after the thirtieth week.

A brief but concise discussion of the problem of postmaturity is given, and work is cited which suggests that the cases of so-called postmaturity probably are really instances of slow maturation. If this be true, it would explain the commonly known fact that there are no reliable criteria for establishing the diagnosis of postmaturity in the fetus. It is certainly well known that by x-ray examination of the ossification centers before or after birth, it is impossible to tell the fetal age within one month.

Three charts.

GEORGE C. BARRETT, M.D.
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THE GENITOURINARY SYSTEM

A Clinical Evaluation of Nephrotomography. W. F. W. Southwood and V. F. Marshall. Brit. J. Urol. **30**: 127–141, June 1958. (W. F. W. S., New York Hospital, New York, N. Y.)

Nephrotomography as described by Evans *et al.* (Radiology **64**: 655, 1955) has been evaluated from the clinician's point of view. Twenty of the authors' first 272 consecutive nephrotomographic studies were considered as being so technically inadequate that a diagnosis was not rendered. In the remaining 252 cases a diagnosis was made, although it cannot be said that all were ideal. In 93 instances the kidneys were reported as normal; in only 4 of these cases has a misdiagnosis been detected, but long-term follow-ups are not available and for that reason the value of the method for excluding renal disease cannot be stated clearly at present.

Nephrotomography is of particular value in indicating whether an intrarenal mass is or is not a non-neoplastic cyst. Simple cysts larger than 1 to 2 cm. in diameter nearly always show up quite characteristically. The existence of a simple cyst, however, does not exclude the possibility of a simultaneous or later developing neoplasm, although in the present series no example of simple cyst and cancer in the same kidney was encountered. While the authors are hesitant to aspirate renal masses of unknown type, when nephrotomography indicates that the mass is a cyst, and incidentally aids in its location, they are much more freely inclined toward a simple aspiration through the flank, with examination of the fluid thus obtained for tumor cells. By following such a plan, surgical exploration was eliminated in a significant number of patients (probably 25), including several who were poor operative risks.

When nephrotomography does not reveal the presence of a cyst, the possibility of a neoplasm is of course vastly increased. If the mass opacifies, and especially if it does so irregularly and without sharp outlines, the probability of neoplasm is very great. In some neoplasms central necrosis occurs, but these have usually been detected because of the blotchy, irregular opacification of the neoplasm about the necrotic center and the fact that the lucent area is rarely circular and sharply defined on the tomographic films. If there is good suspicion that there is a neoplasm, the diagnosis should be confirmed surgically.

The authors do not believe that nephrotomography is highly reliable in the diagnosis of neoplasms, particularly small ones, in the renal parenchyma. On the basis of their series, it appears that the procedure is 90 to 95 per cent accurate in the differentiation of simple cysts and neoplasms of the kidney. Its greatest value probably lies in the study of poor risk patients in whom good evidence of a cyst would eliminate the need for operation.

No serious reactions and no fatalities were encountered in this series of 272 cases. Such reactions as were experienced were those occurring after the injection of most of the usual contrast media employed for excretory pyelography.

Sixteen roentgenograms with accompanying drawings.

The Transperitoneal Removal of Certain Vesical Diverticula and a Radiographic Technique for Diagnosis. L. N. Pyrah and P. G. Keates. Brit. J. Urol. **30**: 168–179, June 1958. (L. N. P., University of Leeds, Leeds, England)

Diverticula of the bladder of medium or large size are not uncommonly found in the male as a complication of bladder-neck obstruction produced by small, fibrous, or adenomatous prostates or by fibrosis of the bladder neck; occasionally they may complicate urethral stricture. They are rare in the female. The small, intramural saccules which can so often be seen cystoscopically in the bladder of prostatic obstruction are usually unimportant clinically. The larger ones, sometimes as big as the bladder itself, are of considerable surgical significance. Large diverticula must be excised when the bladder-neck obstruction is removed (simultaneously or in sequence); if the obstruction is removed and the diverticulum left behind, there may be a persistent infection and also a high residual urine, causing frequency of micturition and sometimes retention. The authors prefer to remove the diverticulum and the prostate at the same operation; sometimes a small prostate has been resected and the diverticulum excised a fortnight later.

Roentgenography has proved valuable in selecting cases for the transperitoneal operation which the authors advocate. A routine anteroposterior view of the bladder during excretory urography is taken with the patient lying flat on the x-ray table and with the central ray directed 15° caudal to the sagittal plane, in order to avoid superimposing the shadow of the symphysis pubis on that of the base of the bladder; the organ is then seen free from overlying bone shadows. This is especially helpful when the concentration of contrast medium is not very high, as in excretory urography. It has the disadvantage, however, that the back and front of the bladder are superimposed and lesions may be missed. By taking further views with the patient

rotated 45° to the left and to the right, this defect may be partially overcome but full visualization of the back of the bladder is not obtained. The authors have found roentgenograms of the bladder taken by the Chassard-Lapiné technic (see, *e.g.*, Radiology **54:** 392, 1950) or the "squat shot" (J. Urol. **70:** 969, 1953. Abst. in Radiology **63:** 615, 1954) give a clear picture of anatomical relationships, often with demonstration of the neck of the diverticulum.

Ten cases of bladder diverticulum successfully treated by transperitoneal diverticulectomy are reported.

Twelve roentgenograms; 6 drawings; 1 photograph.

The Occurrence and Significance of Vesico-Ureteral Reflux in Children. W. I. Forsythe and R. F. Whelan. Brit. J. Urol. **30:** 189–197, June 1958. (Queen's University, Belfast, Ireland)

During the investigation of children by micturating cysto-urethrography, a reflux of contrast material from the bladder into one or both ureters was seen on a number of occasions. The present study was carried out to determine the frequency of this phenomenon and to establish its relationship, if any, to abnormalities or infections of the urinary tract. In a number of selected cases a detailed examination of the vesico-ureteral reflux was made in an attempt to relate the time and degree of its occurrence to the state of filling or emptying of the bladder.

Four hundred and forty-five children between three and fifteen years of age were examined by micturating cystourethrography: 430 children had enuresis, 10 urinary infection, and 5 had miscellaneous symptoms. A vesico-ureteral reflux occurred in 61.

The patient was asked to empty the bladder and the act of micturition was observed. With aseptic precautions a rubber catheter was passed, and the patency of the external meatus and the ease of passage of the catheter through the urethra were noted. The amount of residual urine was recorded. A sterile 25 per cent suspension of barium sulfate was injected slowly, *i.e.*, about 50 ml. per minute, until the patient indicated a desire to void, and the capacity of the bladder was observed. An oblique view of the urethra and base of the bladder was obtained with the patient in the supine position, the left leg extended and the right hip joint flexed to an angle of 45°, and the pelvis rotated about 35° to the right. The x-ray tube was rotated 5° toward the patient's head so that the central ray was directed at right angles to the bladder outlet. Micturition was performed in successive stages, during which three or four exposures were made.

Findings indicated that lower urinary tract obstruction is not a common cause of vesico-ureteral reflux in children, and that other abnormalities, *e.g.*, wide bladder-neck anomaly, are not commonly associated with vesico-ureteral reflux. There was a high association between vesico-ureteral reflux and megaureter, particularly with pyelitis, but whether the infection was the cause of the reflux or *vice versa* was not clear.

Fifteen children were examined in detail in the upright position, and it was found that the reflux was not confined to any one stage of filling or emptying. The height of the reflux did not seem to depend on whether the patient was in the supine or vertical position.

In the present series, 30 children showed a vesico-ureteral reflux without any other apparent abnormality of the urinary tract, *i.e.*, there was no evidence of neurogenic uropathy, *e.g.*, spina bifida with neurologic signs, no history of previous urinary infection was obtained, and repeated examinations of urine were normal.

Fifteen roentgenograms; 1 graph; 1 table.

The Peripheral Control of Micturition: A Cine-Radiographic Study. Marco Caine and David Edwards. Brit. J. Urol. **30:** 34–42, March 1958. (Institute of Urology, University of London, England)

The authors report an investigation into the control of micturition and the mechanism of urinary continence, using an image intensifier. Studies were concerned with the peripheral components of the controlling mechanism, in particular the actions of the muscles adjacent to the urethra. Central nervous mechanisms and pathways were not explored. Ten normal persons, 34 postprostatectomy patients with normal control, and 10 patients with incontinence after prostatectomy were examined. The technic employed is described.

The appearances in the normal subject at rest, after the bladder has been filled with contrast medium, are those familiar in the ordinary cystogram. The base of the bladder is flat, the internal meatus is usually completely closed, and the urethra empty and hence not delineated. When micturition is begun, the stream of opaque fluid is seen to pass along the urethra, and at the same time there is a well marked descent of the bladder base. This, together with the corresponding ascent that occurs on the cessation of micturition, has already been observed and stressed by Muellner and Fleischner (J. Urol. **61:** 233, 1949. Abst. in Radiology **54:** 148, 1950). Special attention is drawn to a feature termed "reflux emptying" of the posterior urethra, seen on the voluntary discontinuance of micturition.

The control after prostatectomy is seen to be strictly comparable with the normal. In particular, the reflux emptying still takes place from the external sphincter, either to the prostatic cavity or to the bladder neck. It is stressed that the lower extremity of the resting column of urine, when the bladder neck is incompetent and a prostatic fossa remains, is at the lower extremity of the prostatic fossa, and *not* at the external sphincter as is usually stated.

The concept of a dual mechanism in normal continence is proposed, and the components are designated "active continence," by which is meant the mechanism brought into play when a voluntary effort is made to interrupt the act of micturition or prevent the unwanted escape of urine, and "passive continence," which refers to the continence maintained in the normal relaxed state, when no active sphincteric contraction is being made.

Examination of cases of postprostatectomy incontinence shows an absence of reflux emptying, and this is correlated with the concept of active and passive continence.

Bilateral pudendal nerve block after prostatectomy is found not to produce incontinence, thus supporting the contention that the external sphincter is not the structure maintaining passive continence in the postprostatectomy subject.

The authors express the hope that this investigation has helped to define the nature of the peripheral mechanism of continence after prostatectomy and to establish the exact location of the damage in the patient with postprostatectomy incontinence. The use of the

concept of "active continence" and "passive continence" should help to clarify the approach to problems arising in the control of micturition and its impairment.

Twenty-three roentgenograms, with accompanying drawings.

Deduction of Chemical Composition of Urinary Calculi by Radiological Means. George Cohen. South African M. J. **32**: 1089–1091, Nov. 8, 1958. (Johannesburg General Hospital, Johannesburg, Union of South Africa)

Radiological reports refer to the presence of urinary calculi, but hardly ever attempt to analyze their chemical composition. Such deduction can, however, often be made from an ordinary roentgenographic examination, and it may be of importance as pointing to the presence or absence of infection (for some stones develop only in infected urine) or as indicating that the stone will be easily crushed or crushed with difficulty.

The accompanying table summarizes the author's findings.

DEDUCTION OF CHEMICAL COMPOSITION OF URINARY CALCULI BY RADIOLOGICAL MEANS (COHEN)

In Decreasing Order of Density	Order of Incidence	Order of Rate of Growth	Age	Number	Shape	Size	Surface	Notes
Calcium carbonate (O)	4	6	A	S/M	...	...	...	Septic; alkaline urine
Calcium oxalate (O)	1 (*a*)	7	40 yr.	S	"Mulberry" or "thornapple" especially in bladder	Not large in kidney, but "pigeon's egg" in bladder	Irregular if large, smooth if small	Pain and hemorrhage always severe
Calcium phosphate (O)	2	1 (*b*)	A	M	"Stag-horn" or "renal cast" and faceted	Largest of all types	...	Occasional flake fracture of stone
Triple phosphate (O)							Smoother than calcium phosphate stone	Septic; alkaline urine
Cystine (O/T)	6	2	I/A	S/M	Oval or round "stag-horn" in children	Small	Smooth—never found in ureter (slips down into bladder)	Familial cystinuria; usually aseptic
Urates (T)	3	5	I	M	Flattened ovoid or round	Small/moderate	Usually smooth; occasionally rough and finely modulated	Occasional fracture of stone
Uric acid (T)	5	3	Y	M	Faceted	Small	Smooth—never found in ureter; (slips down into bladder)	Spontaneous fracture common
Xanthine (T)	7	4	A	S/M	...	...	...	Acid urine

O. Opaque. T. Translucent. (*a*). Most frequent. (*b*). Quickest growing. I. Infant. Y. Youth. A. Adult. S. Single stone. M. Multiple stone.

MISCELLANEOUS

Radiologic Possibilities in the Diagnosis of Lumbar Aortic Lymph Node Enlargement by Means of Retroperitoneal Air Insufflation. G. Carnevali and S. Di Pietro. Radiol. med. **44**: 858–878, September 1958. (In Italian) (Università di Milan, Milan, Italy)

The authors point out the importance of early diagnosis of lymph-node enlargement as in lymphoma and metastatic involvement from testicular tumors and elaborate on the difficulties of diagnosing minor increases by conventional means. Retroperitoneal air studies were found to be of great value in cases in which lymph-node enlargement was uncertain, and the patients suffered from systemic lymphoma or seminoma. Their accuracy was enhanced by the addition of laminagraphy. The enlarged nodes appear as sharply outlined, wavy, curvilinear densities, which arise asymmetrically from the soft tissues surrounding the spine and merge with the paravertebral soft tissue on their medial aspect. Isolated masses the size of a walnut can be identified, and smaller nodes in the region of the psoas muscles can be detected by the bulging of the external outline of the muscle. It is not difficult, say the authors, to distinguish between this condition and hypertrophy of the psoas muscles. In order to demonstrate enlargement of nodes that are located more anteriorly, transverse planigraphy may be necessary.

The authors point out the importance of being familiar with the normal anatomy of the region by means of laminagraphy and retroperitoneal air studies. The root of the mesentery, the aorta itself, the duodenum, and the pancreas present shadows that can and should be differentiated from the nodes. It is difficult, however, to distinguish radiographically between the head of the pancreas and a lymph-node mass in the right paravertebral region. It is almost impossible to differentiate para-aortic lymph-node enlargement from primary retroperitoneal neoplasms, although the outline of the nodes is frequently clearer and is wavy. The nodes do not show calcification and air diffuses more easily in them. The history is usually also helpful. None of these signs, however, is absolute.

Thirteen roentgenograms.

ALEXANDER R. MARGULIS, M.D.
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Adult Agammaglobulinemia Associated with Multiple Congenital Anomalies. Samuel Zelman and Hans Lewin. Am. J. Med. **25**: 150–154, July 1958. (H. L., VA Hospital, Topeka, Kans.)

A patient with adult agammaglobulinemia characterized by recurring pyogenic infection, a sprue-like syndrome, and reticuloendothelial hyperplasia of the spleen and lymph nodes, with granuloma formation, was found to have multiple congenital anomalies. Roentgen examination showed the spleen, liver, stomach, and duodenum all to be on the right side, leaving only the descending colon and the jejunum in the left side of the abdomen. The lower part of the esophagus turned to the right and entered the abdominal cavity through a hiatus of the diaphragm close to the midline. The descending duodenum turned anteriorly, and the third or transverse portion was very short. The jejunum, the ileum, and the colon, except for a high splenic flexure reaching the left diaphragmatic leaf, were not abnormal, nor were any anomalies of the urinary tract discovered. There were roentgenographically demonstrable anomalies of the skull, spine, and left humerus, as well as clubbed fingers and an osteochondroma of the left humerus.

A hereditary basis in the authors' case is suggested by the presence of hypergammaglobulinemia in both parents.

Seven roentgenograms; 3 photomicrographs.

Tuberous Sclerosis, with Particular Attention to the Roentgenologic Aspect. L. Psenner and E. Schönbauer. Fortschr. a. d. Geb. d. Röntgenstrahlen **89**: 301-318, September 1958. (In German) Allgemeinen Krankenhaus, Vienna, Austria)

Tuberous sclerosis (Bourneville's disease) is characterized by the presence of tumor-like foci in the central nervous system, skin, kidneys, heart, eyes, and lungs. Certain changes occur in the bones and idiocy, epilepsy, and sebaceous adenomas of the skin are usually associated. The disease is hereditary (dominant type) and progressive. Most patients die before the age of thirty.

Of the radiological signs, the endocranial calcifications are best known. These may occur in any part of the brain and are either homogeneous, rather dense calcified foci, 3 to 10 mm. in diameter, or much larger granular calcifications, similar to those occurring in gliomata. Both types are probably based on a hamartoma, *i.e.*, a tumor-like malformation. Sometimes the granular calcifications grow independently in size (hamartoblastoma) a feature which is prognostically unfavorable. Structural changes in the cranium, such as thinning and thickening, are also observed. In the shafts of the metacarpal and metatarsal bones, as well as in other long bones, thickening of the compact substance may occur, caused mainly by endosteal bone apposition which diminishes the marrow space, and, to a lesser degree, by periosteal bone apposition. Step-like bone defects along the anterior edge of the vertebral bodies, seen on the lateral view, were noticed by the authors in one of their cases. Small nodal densities, resembling a miliary tuberculosis, occasionally occur in the lungs.

One case is described in detail and the differential diagnosis is thoroughly discussed.

Nineteen roentgenograms.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

The Nisbet Symposium: Collagen Disease. Part 1: General Aspects. R. B. Lefroy. Proc. Coll. of Radiologists of Australasia **2**: 1–5, September 1958.

The author would discard the term "collagen diseases," under which have been grouped such conditions as rheumatic fever, rheumatoid arthritis, polyarteritis nodosa, dermatomyositis, scleroderma, and disseminated lupus erythematosus, and replace it by "connective-tissue disorders." Connective tissue actually consists of fibers (which are mainly collagen), of fibroblasts, which are the main constituent of the cellular element, and of the so-called "ground substance." It seems probable that collagen originates from the fibroblasts and the ground substance. The latter is a sort of plastic fluid containing water, electrolytes, and various colloids—among them the important mucopolysaccharides and other protein complexes.

The behavior of connective tissue appears to be guided by three main influences: enzymes, hormones, and vitamins. Examples of the enzymes concerned are: the hyaluronidases and heparin, which apparently inhibits hyaluronidase. Among the vitamins of importance is ascorbic acid, in the absence of which collagen is not laid down. The hormones to be considered are thyroxin and the corticosteroids.

The principal manifestations histopathologically of the collagen or connective-tissue disorders are: proliferation and degeneration. In rheumatoid arthritis the accent is on proliferation. In scleroderma, also, there is proliferation of collagen fibers. In rheumatic fever, rheumatoid arthritis, lupus erythematosus, and dermatomyositis, there are evidences of mucoid degeneration.

The term fibrinoid degeneration or necrosis, which has often been linked with the collagen diseases, has led to much misinterpretation and misunderstanding. Fibrinoid does not have its origin from collagen in all cases and one etiologic factor is certainly not responsible for all evidences of fibrinoid degeneration. Considerable criticism is leveled at Klinge's hypersensitivity hypothesis for all cases.

Some disease conditions on the fringe of connective-tissue disorders must be mentioned, as myxedema, scurvy, amyloidosis, and multiple myeloma.

The author concludes with the statement that etiologic factors are largely obscure but it seems likely that further knowledge will come from a study of globulin fractions and immune responses, rather than the histologic characteristics of collagen.

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The Nisbet Symposium: Collagen Disease. Part 2: The Arthritides. Phyllis B. E. Goatcher. Proc. Coll. of Radiologists of Australasia **2**: 5–10, September 1958.

The purpose of this short paper is to attempt to clarify a few points in the clinical diagnosis of rheumatoid arthritis. Radiology may be most helpful. The only drawback is that considerable time may elapse before demonstrable changes occur, though it has been claimed that 80 per cent of changes are to be found within six months of the onset. The author emphasizes the need for repeat x-ray examinations of the hands and feet at regular intervals.

Six roentgenograms; 1 photomicrograph; 1 photograph; 2 tables. JAMES F. MARTIN, M.D.
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The Nisbet Symposium: Collagen Disease. Part 3: The Radiological Changes. B. F. Vaughan. Proc. Coll. of Radiologists of Australasia **2:** 11–16, September 1958.

Of the three papers constituting the Nisbet Symposium on Collagen Diseases (see two preceding abstracts), this is the one of chief concern to the radiologist. In rheumatoid arthritis the first change in the joints of the extremities is osteoporosis, which may be generalized or juxta-articular. This, however, is a non-specific finding; the earliest manifestations establishing a specific diagnosis are surface articular erosions. These erosions will usually occur within six months of onset of the disease, but in some cases may not appear for several years. As the disease progresses, the erosions become irregularly enlarged and are associated with narrowing of the joint space, subluxations, and ankylosis. The cystic erosions may resemble gout, but the tendency for gout to involve the feet and the lack of symmetrical distribution in that disease are aids in the differential diagnosis.

In Still's disease, the changes are similar to those of rheumatoid arthritis, with the addition of periostitis along the metacarpals and phalanges. In addition bones adjacent to those involved by Still's disease in children will show a curtailment of normal growth. Metacarpals and phalanges may be smaller than normal and the cervical spine may exhibit small fused vertebral bodies. When the spine is involved, a differential diagnosis must be made between rheumatoid arthritis and ankylosing spondylitis.

In disseminated lupus erythematosus, the arthritic change is manifested by deformities and osteoporosis without erosion or joint narrowing. Lupus erythematosus may, however, develop in a patient with rheumatoid arthritis, complicating the differential signs.

Scleroderma produces a generalized atrophy of the soft tissues, and the joints become fixed and deformed by these changes. Osteoporosis of the involved bones and resorption of the terminal phalanges of the hands and soft-tissue calcification are diagnostic criteria.

Thirteen roentgenograms; 2 tables.

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RADIOTHERAPY

Orthovoltage Therapy. Is There Still a Need for It? Sol R. Baker. California Med. **89:** 420–422, December 1958. (119 N. San Vicente Blvd., Beverly Hills, Calif.)

The author considers it premature to abandon orthovoltage roentgen therapy in favor of supervoltage treatment as long as the superiority of the latter is not definitely proved by increased cure rates. Although supervoltage therapy has some distinct advantages, as increased depth dose, decreased bone absorption, and fewer local and systemic reactions, it also has disadvantages, *e.g.* deep tissue damage, less relative biological efficiency, and increased cost. The variety of supervoltage machines indicates that the best one has not yet been found.

Belief that higher voltage means cure may lead to disillusionment, as radiotherapists may attempt to treat patients who should not be irradiated at all. The author considers that the particular radiation modality used is of less importance in determining the therapeutic result than the histologic character and extent of disease. He advises improved training of radiotherapists, concentration on orthovoltage therapy, limitation of supervoltage technics to large centers with a considerable volume of patients and highly trained personnel until better assessment of supervoltage therapy value can be obtained.

W. TOPOLNICKI, M.D.
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Malignant Lesions of the Nasopharynx. Paul W. Scanlon, Kenneth D. Devine, and Lewis B. Woolner. Ann. Otol., Rhin. & Laryng. **67:** 1005–1021, December 1958. (Mayo Clinic, Rochester, Minn.)

The authors analyzed 88 cases of primary nasopharyngeal cancer encountered at the Mayo Clinic during the years 1945 to 1949. The ages of the patients ranged from five to seventy-eight years, with an average of forty-five; 80 per cent were male. The lesions in 19 per cent were squamous-cell epitheliomas, in 67 per cent lymphoepitheliomas, in 5 per cent lymphosarcomas, and in 9 per cent a miscellany including small-cell carcinoma, cylindroma, and others.

In 23 per cent of the cases the tumor was confined to the nasopharynx. In 47 per cent it had spread to the regional nodes. In 12 per cent there was evidence of cranial nerve involvement. In 16 per cent there was both lymph node and cranial nerve involvement. Two per cent had only evidence of distant spread.

In 11 of the 88 cases there was roentgenologically demonstrable destruction of the floor of the middle fossa in the region of the foramen lacerum. This figure is lower than the average in other series, primarily because base views of the skull were not obtained in all cases. Stereoscopic base views are recommended as the most reliable method of determining the presence of bone destruction.

Details of treatment are not very clear. Sixty-four patients (73 per cent) were treated with the nasopharyngeal application of radium in conjunction with externally administered roentgen therapy. The five-year survival rate in this group was 17 per cent, differing in no respect from that of patients who received external therapy alone. Only 21 of the 88 cases (24 per cent) received what the authors designate as high-dose therapy, *i.e.*, a midplane tumor dose in excess of 3,500 r delivered in three to four weeks. The remainder received what today is considered a suboptimal dose. There was, however, no apparent correlation between the magnitude of the tumor dose administered and the survival rates, an experience reported by others. Intranasal-pharyngeal topically applied radium was of no apparent value.

For tumors confined to the nasopharynx at the beginning of treatment the five-year survival rate was 30 per cent. When the disease extended to the regional lymph nodes only, the five-year survival rate was 15 per cent; when the floor of the middle fossa was destroyed or the cranial nerves were involved, 27 per cent. No five-year cures were obtained when both types of metastatic spread were present. Survival for five years in all cases of involvement of the regional

nodes was 11 per cent, and in all cases of involvement of either bone or cranial nerve was 12 per cent.

All of the survivors belonged to the lymphoepithelioma and lymphosarcoma groups.

Eight tables. MAJ. MARTIN A. THOMAS, M.C.
MacDill AFB, Tampa, Fla.

Carcinoma of the Larynx. Glenn E. Sheline and Robert S. Stone. Ann. Otol., Rhin. & Laryng. **67:** 1066–1072, December 1958. (University of California Medical Center, San Francisco, Calif.)

At the authors' institution radiation therapy is given preference in all cases of carcinoma of the larynx. Surgery is reserved for those cases thought uncontrollable by radiation and for radiologic failures. Radiation is usually administered through right and left opposing 5 × 5 cm. ports. With 1,000-kvp radiation (9 mm. Cu h.v.l.) 5,500 to 7,000 r was given in twenty-five to thirty-five days. Another group of patients were treated with 200-kvp radiation (1 mm. Cu h.v.l.), the tissue dose being 5,000 to 6,000 r in thirty to forty days. Eighteen patients more recently treated received 400-kv irradiation (4.6 mm. Cu h.v.l.) with tissue doses of 5,500 to 6,500 r in thirty-five to forty days.

Of the series of 124 cases reported here, 96 were treated by irradiation alone. The lesions were staged as follows: Stage 1: The carcinoma is limited to the tissue of origin and is freely mobile. These cases can also be handled by laryngofissure and chordectomy. Stage II: The carcinoma infiltrates and may extend beyond the tissue of origin but not beyond the larynx. Mobility of the vocal cords may be impaired or lost. These cases can be treated by total laryngectomy. Stage III: There is extra-laryngeal extension of the carcinoma. This stage includes mobile ipsilateral lymph-node metastasis. Stage IV: This stage comprises cases with contralateral, fixed, or distant lymph-node metastasis and those with other primary malignant neoplasms previously diagnosed and uncontrolled. The last two stages are inoperable by total laryngectomy, although patients in Stage III may occasionally be considered for more extensive surgery.

Ninety-six cases were treated by irradiation alone with control of the disease in 58, as follows: 30 Stage I cases, 24 (80 per cent) five-year survivals; 43 Stage II cases, 29 (67 per cent) five-year survivals; 19 Stage III cases, 5 (26 per cent) five-year survivals; 4 Stage IV cases, no five-year survivals. In 2 patients with Stage I disease and 2 with Stage II, laryngectomy was required because of radiation sequelae. Most of the 54 remaining survivors had good laryngeal function.

There was no correlation between the quality of radiation used and the survival rate. Two radiation failures were controlled by secondary laryngectomy.

Complications included late chondral necrosis in 2 cases; 1 case of intractable edema of the vocal cords; neurologic symptoms suggesting radiation myelitis in 1 patient. In 3 cases squamous-cell carcinomas appeared within the treated area seven and one-half, eight and one-half, and twelve years after therapy: in the posterior hypopharyngeal wall, on the previously uninvolved vocal cord, and in the pyriform sinus respectively.

Three tables. MAJ. MARTIN A. THOMAS, M.C.
MacDill AFB, Tampa, Fla.

Ankylosing Spondylitis. F. Dudley Hart. Brit. M. J. **2:** 1082–1083, Nov. 1, 1958. (Westminster Hospital, London, England)

Two hundred and nine returns were made to a questionnaire sent in the Spring of 1958 to 343 patients with ankylosing spondylitis seen at Westminster Hospital since the Second World War. The disease had its onset before the beginning of the War in 23 cases, in 1940–1944 in 58, in 1945–1949 in 75, in 1950–1954 in 44, since 1954 in 9. Four returns were from relatives of deceased patients and 5 were incomplete.

Of those making complete returns, 160 (80 per cent) stated that they were working full time; 19 were capable of modified duties, and 12 of light or occasional work; 9 were permanently incapable of any work.

Of 191 patients who answered questions relating to their general health, 36 stated that it was excellent, 74 good, 71 fairly good, and 10 poor. Eleven complained of severe and 38 of moderate dyspepsia. Roentgen examination in 37 cases revealed peptic ulcers in 10.

Deep x-ray therapy to the spine had been given 143 patients. A few treated elsewhere received a total dosage above 1,500 r to some part of the spine; the majority received less than 1,200 r. Details of the administration have been given elsewhere (Hart et al. Quart. J. Med. **18:** 217, 1949). Of the 143 patients, 114 (80 per cent) derived some benefit; 41 (28.7 per cent) claimed some measure of lasting relief, continuing two months to seventeen years after treatment. Twenty-seven of these 41 were irradiated over four years previously. Thirty reported transient improvement lasting six months or less, 18 improvement for periods of seven months to five years, 3 for more than five years. Thirty-two of the 114 (28 per cent) patients experienced some symptomatic relief for periods exceeding four years. Caution is necessary, however, in interpreting these figures, for "improvement" may be falsely attributed to therapy when natural remission has occurred and is usually based on pretreatment symptoms, *i.e.*, symptoms of exacerbation may be compared with symptoms of remission. All that can be said at present is that some measure of symptomatic improvement occurred after therapy.

To the question "What medicines have you found most helpful for your spondylitis?" 43 answered none, 49 aspirin in some form, 54 compound codeine tablets, 56 phenylbutazone, and 9 steroid therapy. Only a small minority has been offered the last treatment. This confirms the author in his opinion that phenylbutazone, if tolerated, is the single most useful drug for spondylitis in all stages.

RADIOISOTOPES

The Immediate Uptake of Radioactive Iodine as a Test of Thyroid Function. Helen E. A. Farran. Brit. M. J. **2:** 1060–1062, Nov. 1, 1958. (New End Hospital, London, N.W. 3, England)

A simplified version of other thyroid-function tests based on clearance rates of radioactive idoine is described. It is easy to perform; results can be obtained less than an hour after its request; it has the advantage, particularly if I^{132} is used, that the radiation received is practically negligible, so that serial tests can

be made safely on the same person over a long period of time.

Four scintillation counters with sodium iodide crystals, 3.8 cm. in diameter and 2.5 cm. long, are used. Each crystal is backed by a Perspex light guide, 3.8 cm. in diameter and 1.9 cm. long, which forms the optical connection to a photomultiplier. The pulses from the four counters are fed into a mixer unit and from there, through an amplifier, to a ratemeter which is connected to a pen recorder. The counters are mounted in cylindrical lead shields 5 cm. thick, which are positioned so as to form a ring 20 cm. in diameter. The patient is seated in a dental chair which can be adjusted so that the counters are at the level of the thyroid. The background radiation under the conditions of the test is first measured. Normal saline containing 3–5 μc of either I^{131} or I^{132} is then injected intravenously and the uptake of the radioactive iodine is continuously recorded for thirty minutes. From this record an arbitrary quantity, *S*, is obtained which is used as a criterion of thyroid function.

This test has been used in 357 people in whom the clinical diagnosis was reasonably certain, and a good separation between thyrotoxic and euthyroid subjects was obtained in about 90 per cent of the cases. The test has proved most useful in investigating the effects of drugs on thyroid function, where several tests are often required on the one person. It is not possible to say whether or not it is of value in the diagnosis of hypothyroidism until more proved cases have been studied.

Two photographs; 2 graphs.

Study of Fat Absorption Utilizing I^{131}-Labeled Corn Oil in Infants and Children With and Without Steatorrhea. Samuel Spector, LeRoy W. Matthews, Frances J. Lemm, Ymkje Van Erp, and Jean Cline. Pediatrics **22:** 515–524, September 1958. (S. S., 2103 Adelbert Rd., Cleveland 6, Ohio)

A method for measuring the absorption of I^{131}-labeled fat is presented. I^{131} labeled corn oil was prepared by a technic similar to that described by Stanley and Thannhauser (J. Lab. & Clin. Med. **34:** 1634, 1949). A test meal was made ready immediately before use by emulsifying the following in a blender for three minutes: I^{131}-labeled corn oil, 1 μc/kg. body weight, and nonlabeled corn oil sufficient to bring the total to 1 ml./kg. body weight, plus an equal amount of concentrated orange juice and an equal amount of water. This mixture proved palatable and was administered to the child in the fasting state. Infants received the I^{131} corn oil mixture without orange juice. Breakfast or the regular feeding was given within one-half hour after the test dose and regular feedings followed during the remainder of the test period. All feces and urine were collected separately over a forty-eight-hour period. Blood samples were obtained at two, four, six, eight, twelve, and twenty-four hours. The isotope content of stool and urine samples was determined by scintillation counting. The isotope content of the blood was determined by direct counting, with an end-window Geiger tube or windowless flow counter, of 0.05 to 0.1 ml. of capillary blood plated out on a lens paper disk in a planchette. All children received 5 drops of a saturated KI solution daily for two days before and during the investigation period to block I^{131} uptake by the thyroid gland.

Studies were done on a "normal" control group of 33 children (convalescing from diseases not involving the gastrointestinal tract); 13 children with cystic fibrosis of the pancreas, and 5 with clinical evidence of celiac syndrome. In the normal group the degree of fat absorption, by the method presented, appeared to be a function of age. In infants and children with cystic fibrosis of the pancreas the test provides a means of establishing the lipolytic function of the pancreas and the efficacy of the addition of pancreatic extracts to the diet. The test also makes possible recognition of the presence and severity of the celiac state where it is a factor in malnutrition.

Three charts; 6 tables.

Successful Radioiodine Therapy in Two Cases of Metastasizing Carcinoma of the Thyroid. J. H. Müller. Radiol. clin. **27:** 398–402, November 1958. (In German) (Kantonsspital, Zurich, Switzerland)

Two cases of successful radioiodine treatment of metastasizing carcinoma of the thyroid are reported in some detail. A 22-year-old woman was treated in 1947 and a 26-year-old man in 1950. In each one, the tumor was relatively highly differentiated, partly papillary adenocarcinoma with moderate colloid formation. At the time of the report both patients had been followed for a period of five years and were free of symptoms. Each had become a parent of healthy children since therapy.

Fractional ingestion of the radioiodine should be continued as long as required to irradiate thoroughly all the iodine-storing tissue, as total athyreosis is obligatory.

Two photomicrographs; 1 photograph.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

Intravenous Radioactive Gold in the Treatment of Chronic Leukemia. Comparison of Results with Conventional Roentgen Therapy to the Splenic Area. P. F. Hahn, D. G. Lareau, B. L. Feaster, E. L. Carothers, F. Gollan, G. R. Meneely, and D. Sherman. Acta radiol. **50:** 565–572, December 1958. (VA Hospital, Nashville, Tenn.)

In 17 patients with chronic myelogenous or chronic lymphogenous leukemia, treatment by x-ray irradiation to the spleen was alternated with intravenous administration of radioactive gold to determine the relative efficacy of the two methods. There were sufficient uncomplicated remissions among the patients to permit evaluation of the procedures; and in 1 patient 6 alternating gold- and roentgen-induced remissions were studied. Reports of 2 of the typical cases are given.

It was found that neither method lengthened the life span of the patient, and clinical responses to treatment were essentially the same in each. Remissions lasting from three to six months were the rule.

The radioactive gold administration produced less nausea and required less time and expense, since it could be given as a single injection to an ambulatory patient.

One patient received 100 mc of colloidal gold for his first treatment, instead of the usual initial 50 mc, and this was followed by remission of two and one-half years.

The authors suggest that perhaps higher doses of gold should be tried in managing cases of chronic leukemia.

Two case reports. DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Inhalation Radiocardiography. C. H. Jaimet, R. H. Tomlinson, and P. F. Nace. Canad. M. A. J. **79:** 972–977, Dec. 15, 1958. (McMaster University, Hamilton, Ont.)

This report deals with the investigation of several functions of the heart by means of inhalation radiocardiography. Radioactive methyl iodide and radiokrypton were administered by inhalation and a special counter was placed over the heart area posteriorly for recording radioactivity. The authors describe their apparatus and the formulae used in computing the results.

From the tracings obtained, the authors believe this study may be applicable and useful in determining cardiac output and coronary flow. Krypton-cardiograms revealed findings which are against the generally accepted idea that coronary flow in angina is decreased. Coronary flow was shown to be increased in these patients.

Six graphs.

J. S. ARAJ, M.D.
Toledo, Ohio

A Simplified Method for the Urinary Excretion Test of Absorption of Cobalt 60 Labelled Vitamin B_{12}. Howard F. Corbus and Henry Nielson, Jr. California Med. **89:** 400–401, December 1958. (1759 Fulton St., Fresno, Calif.)

The authors describe a simple method for measurement of Co^{60} labeled vitamin B_{12} in excreted urine. This can be done in a small laboratory with the Reed-Curtis scintillation counter. After administration to the patient of a known amount of Co^{60}-labeled vitamin B_{12}, two 24-hour urine specimens are obtained and counted, the readings being compared with a standard sample. The results are expressed as percentage of administered dose.

This same method can be used for radioiodine uptake studies.

One photograph.

W. TOPOLNICKI, M.D.
Cleveland Metropolitan General Hospital

Radiocalcium Studies of Bone Formation Rate in Human Metabolic Bone Disease. Robert P. Heaney and G. Donald Whedon. J. Clin. Endocrinol. **18:** 1246–1267, November 1958. (R. P. H., Creighton University School of Medicine, Omaha 2, Nebr.)

Calcium-45 tracer studies were performed in 12 adult human subjects with and without bone disease. The size of the miscible calcium pool averaged slightly less than 100 mg. Ca/kg. in all except 2 patients with osteitis deformans, in whom the pools were four times that size. A direct relationship between the size of the pool and the rate of bone formation was demonstrated and attributed to the variable contribution of the mass of newly formed bone to the miscible calcium pool.

The model used to interpret the isotope data consisted of a single-compartment system with 2 routes of loss representing urinary and endogenous fecal excretion, and recycling by way of a series of long-period release mechanisms through a third route, representing incorporation of isotope into nonexchanging bone and its subsequent return into the pool at the time of osteolysis. The assumptions, for which evidence is cited, under which the use of this model may be valid are chiefly that the complexus of body calcium compartments behaves operationally as a single compartment, with 3 routes of loss, and that the process of bone formation removes calcium from effective contact with the body fluids, and that bone resorption returns this calcium without significant mixing with other bone calcium, after some minimum time period.

The turnover of the miscible calcium pool in the authors' studies was greatly in excess of combined excretory loss and is therefore presumed to include loss of tracer into nonexchanging bone, in the process of bone formation. A method is described whereby this bone uptake may be estimated quantitatively.

On the basis of a study in 1 normal adult in the present series, and of available studies in the current literature, the normal rate of bone formation is estimated to be approximately 9 mg. Ca/kg./day (mean for 10 subjects: 9.1 ± 3.9 Ca/kg./day). Further studies are needed to establish more specifically the upper and lower limits of normal and to assess changes that may occur with aging.

Perhaps the most striking observation in the present series was the level of bone formation in the 7 patients with osteoporosis. Excluding 1 case complicated by hypoparathyroidism, the rates of the remaining 6 patients were clearly within this tentatively normal range (9.4 ± 1.07). This finding suggests the possibility that the diminished bone mass in osteoporosis may be associated, not with decreased bone formation, but with elevated bone destruction.

A much reduced rate of bone formation was found in 1 patient with uncomplicated hypoparathyroidism, a slightly elevated rate in a young male with familial hyperostosis, and greatly elevated rates in 2 patients with osteitis deformans.

From the time of return of bone isotope into the pool, the biologic life of the shortest-lived species of bone was estimated, and measurement was made of the proportion of total bone formation represented by this recycling. In general, the time required for this earliest recycling seemed to vary inversely with the postulated turnover of bone.

Seven figures; 2 tables.

The Combined Effect of Radiogold and Nitrogen Mustard and Radiogold and Certain Other Compounds on the Ehrlich Ascites Carcinoma. Richard W. Whitehead, Raymond R. Lanier, and Jerry B. Thompson. Cancer **11:** 929–932, September-October 1958.

The authors report their experimental attempts to augment irradiation effects by chemotherapy.

Cells from Ehrlich ascites tumors were injected into the peritoneal cavities of mice, which were then grouped into untreated controls, those treated by irradiation only (intraperitoneal radioactive colloidal gold), those receiving only chemotherapy, and those given both. Tumor cell counts on the ascitic fluid were then made.

Various special supplementary compounds were tried, but only nitrogen mustard was found to potentiate the tumor-inhibiting effect of the irradiation. This effect was pronounced and greater than would be expected if the effects of the agents were merely additive. Results showed that the best inhibiting dose of radioactive gold was also the most toxic dose.

The mode of action or synergistic effect on tumor growth between radiogold and nitrogen mustard is unknown. A relationship to cellular oxygen consumption is suggested.

Two tables; 1 graph.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Gonadal Dose in Canada Arising from the Clinical Use of Unsealed Radioactive Isotopes. H. E. Johns and R. M. Taylor. J. Canad. A. Radiologists **9**: 55–58, December 1958. (H. E. J., Ontario Cancer Institute, Toronto, Ont., Canada)

The authors have calculated the gonadal dose from unsealed radio-nuclides in Canada for the year 1956. The dose to the gonads may arise from the beta particles or gamma rays. Both calculations have been based upon the "standard man." Uniform tissue distribution has been assumed except for certain organs which are known to concentrate large amounts.

The authors summarize their calculations as follows:

Isotope	Dose to Gonads per mc Dose	Dose per Person per Year in 0–30 Age Group	Dose to Age 30
I^{131}	0.45 rad	0.31 mrad	9.30
P^{32}	2.60 rad	0.11 mrad	3.30
Au^{198}		0.00	0.00
TOTAL		0.42 mrad	12.6 mrad

The dose to age thirty from natural background is given as 2,850 mrem.

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The Henry Ford Hospital

RADIATION EFFECTS: PROTECTION

A Comparative Histological Study of Duodenal Damage Produced by Fission Neutrons and Co^{60} Gamma-Rays. S. Lesher and H. H. Vogel, Jr. Radiation Res. **9**: 560–571, November 1958. (Division of Biological and Medical Research, Argonne National Laboratory, Lemont, Ill.)

The duodenum of female CF No. 1 mice was compared histologically and cytologically after exposure to fission neutrons (350 rads) and Co^{60} γ-rays (1,000 rads), doses sufficiently high to kill 90 per cent of the animals in a 30-day period after irradiation.

The duodenum of mice exposed to γ-irradiation recovered completely, and the mice lived beyond the critical three and a half- to six-day period of the "intestinal syndrome." The duodenum of mice exposed to fission neutrons was severely damaged, and less than half of the animals lived beyond the six-day period. Damage to the small intestine played a dominant role in these early deaths. There was a close relationship between the degree of intestinal damage, generalized bacterial infection, and time of death.

Irradiation with fission neutrons produced a high percentage of irreparable chromosome breaks and led to a prolonged delay in cell division. The comparison of duodenal damage and recovery rate suggests an RBE (n/γ) greater than 6 for intestinal sensitivity.

Ten photomicrographs; 1 diagram.

Lethal Whole Body Irradiation: Some Experimental Issues. Peter Ilbery. M. J. Australia **2**: 596–599, Nov. 1, 1958. (Sydney, Australia)

In 1956 experimental work at Harwell showed conclusively that recovery from the effects of lethal total-body irradiation was due to cellular recolonization of the destroyed elements of the host's bone marrow by the unirradiated cells of intravenously injected hemopoietic donor tissue, and not to a humoral stimulation of the host's own bone marrow. This discovery resulted from the production of a chromosomal translocation during experiments in radiation genetics. The value of this translocation, designated T6, is that cells derived from mice carrying the translocation can be identified in metaphase of mitosis by cytologic technics.

Work with the T6 marker has shown that early rapid colonization of the irradiated host's bone-marrow spaces, lymphoid tissue and spleen, and later of the thymus, by the donor tissue, takes place after intravenous injection. Although only one million cells are injected, after colonization and multiplication the donor tissue can now be considerable (perhaps about one twenty-fifth of a mouse's total weight), but by immunological assessment it is an overwhelming amount of donor tissue relative to the irradiated and immunologically depressed host. So that, speaking of antibody-producing reserves, there is now far more of donor tissue than host tissue. In fact, the usual set-up of a small graft relative to a large host is (still immunologically speaking) reversed. Therefore it is quite conceivable that the mechanism of secondary disease (*i.e.*, disease having its onset about the sixth week after irradiation following earlier resuscitation) is due to a chronic antigen-antibody reaction, the direction this time being graft against host.

Further evidence as to the direction of the chronic antigen-antibody reaction being graft *versus* host is seen when the leukemic cell is the immunological marker. For example, CBA mice receiving a CBA leukemia intravenously will die of leukemia in fourteen to twenty-one days. CBA mice receiving the same leukemia and, a week later, 950 rads of total-body x-irradiation and replacement therapy with C57 hemopoietic tissue will die, but at a much later date with signs of secondary disease.

It was possible at Harwell to cure some murine leukemias in their early passages by a suitable schedule of whole-body irradiation and hemopoietic homografting. Other leukemias even in their first passages were incurable. The question of application of these experiments to human leukemia has often been brought up, but there are numerous obstacles to such a procedure. First, there is no known means of forecasting whether or not a given leukemia is relatively radiosensitive. In some murine leukemia experiments, radiation dosage was pushed so high to eliminate leukemia that irreversible damage accrued to other tissues. Second, the technic of lethal whole-body irradiation to man is nonexistent. Fall-off across the tissues of so large a subject makes a difficult technical physical problem. Third, the human LD 100 will vary from person to person as from strain to strain of mice, and from young to old. There are radiation mortality figures only for mice, in which case hundreds of animals are needed to determine the point accurately. Fourth, there remains the question of secondary disease except in the special case in which a twin could be used for hemopoietic homografting. The secondary disease might well be worse than the primary disorder.

Four tables.

Tumorigenesis in Ovaries of Mice after X Irradiation. Mary J. Gutherie. Cancer **11**: 1226–1235, November-December 1958.

Mouse ovaries transplanted to an intrasplenic position show a tendency to tumor formation. Similarly,

ovarian tumorigenesis is noted in mice which have been given low doses of total-body x-irradiation. The author, by studying microscopically the sequence of events occurring in irradiated mice, has attempted to explain tumor development under these conditions. A total of 60 mice were used. Each received 150 r total-body irradiation in six minutes at three days of age. They were then killed at weekly or fortnightly intervals up to forty-one weeks.

The microscopic changes in the ovaries, uterine horns, pituitary glands, and adrenals seemed to refute the idea that tumor production was excited by pituitary response to deficiency of circulating estrogens. It appeared rather to be related to the premature "aging" of the ovaries in an animal otherwise young.

The suggestion is made that tumorigenesis might be expected among the characteristic cells of any other organ if the intimate environment of the cells were changed or unbalanced by noxious agents, aging, etc., as long as the vascular bed and the potential for growth were not seriously impaired.

Twelve photomicrographs.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Lethality in the Rat as a Function of Dose Pattern. Q. L. Hartwig, G. S. Melville, Jr., and T. P. Leffingwell. Brit. J. Radiol. **31**: 701–702, December 1958. (Balcones Research Center, Austin, Texas)

The authors explored the results of lethal doses of radiation in rats, delivered in a single large "acute" dose (1, 136 r of Co^{60} gamma rays at 800 r per minute) or as "chronic" radiation either preceded or followed by a single acute dose of 800 r. The chronic radiation was delivered at a rate of 2 r per hour for seven days for a total of 336 r. The dose rate was judged to be slightly less than the rate at which the animals could repair the acute exposure damage. A group of animals was also treated with the single acute dose of 800 r without chronic exposure.

The single large dose was found to be 100 per cent lethal. No significant differences in mortality were apparent between the group receiving only 800 r acute exposure and the two groups receiving the acute-chronic or the chronic-acute exposures.

One graph; 2 tables. G. E. COADE, M.D.
Indiana University Medical Center

The Effects of Chemotherapy and Irradiation Therapy on the Differentiation of Experimental Tumors. Nathan B. Friedman and Eileen Drutz. Cancer **11**: 1060–1069, September-October 1958.

The tendency of tumor cells to differentiate is enhanced by irradiation; it is inhibited by certain antimitotic agents but not by others. This article reports and compares these effects in various transplantable tumors in mice. Among the tumors treated were neuroblastoma, epidermoid carcinoma, preputial gland carcinoma, mammary adenocarcinoma, Ehrlich ascites tumor, and melanoma. Irradiation to the tumors was given in 400 to 500 r daily doses, carried up to as high as 5,500 r. Nitrogen mustard, urethan, and colchicine were the chemotherapeutic agents studied; they were diluted in distilled water or saline and administered intraperitoneally.

When irradiation or nitrogen mustard was given, there was increased differentiation of the neoplastic cells. Synthesis of nuclear material was inhibited, but synthesis of cytoplasm continued. Keratinization increased in epidermoid carcinomas, and pigmentation increased in a melanoma. Conversely, when colchicine was given, there was interference with cytoplasm synthesis while formation of nuclear material continued; cell differentiation was inhibited. Urethan interfered with both nuclear synthesis and cytoplasmic synthesis.

Since the effect of irradiation or nitrogen mustard is just the opposite of that of colchicine on formation of ribonucleic acid (RNA) and desoxyribonucleic acid (DNA), it may be stated that agents which affect RNA inhibit cell differentiation, while those which attack DNA permit differentiation to continue.

If, as seems likely, the cell differentiation produced by irradiation of tumors is based on the inhibition of DNA synthesis, it appears possible that DNA-RNA ratios might be helpful in predicting tumor sensitivity.

Twelve photomicrographs; 1 table.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Attempts at Modification of the Radiation Response of Neoplasms by the Administration of "Hematoporphyrin." Robert Bases, Alexander Pearlman, Rieva Rosh, and Sidney Rubenfeld. Cancer **11**: 1119–1124, November-December 1958.

The search for radiation potentiators is important basic research for radiation therapy. This paper reports results from a study on the potentiating value of hematoporphyrin.

There is evidence that porphyrins localize in tumors, where they are known to persist for days. Patients with porphyria or those receiving intravenous hematoporphyrin are extremely sensitive to ultraviolet irradiation, and this sensitivity has been thought possibly to extend also to x-rays. It has previously been shown that porphyrins may have either a potentiating effect or the opposite when irradiation is administered (depending upon which porphyrin fractions are given, dose, time of irradiation, etc.)

Irradiation combined with hematoporphyrin injections was given 13 patients with advanced cancer. When the hematoporphyrin was given intravenously, the response to irradiation was no greater than could be expected from irradiation alone. When, however, the hematoporphyrin was injected locally into the tumor, there was evidence of potentiation of the radiation effect in 1 of 5 patients.

The authors point out that there are good theoretical grounds for believing that hematoporphyrin might be a promising potentiator, but at present there is a lack of chemical homogeneity in the available samples of the drug. Differences in localization in tumor tissue and in the increase in the tumoricidal effect of irradiation cannot be clarified until the exact effective porphyrin fraction is identified and the material standardized. When this is done, comparisons of experimental results by different investigators can be made, and the search for potentiators can continue in an orderly manner.

Two tables. DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Compatibility Factors Influencing the Acceptance of Rat Bone Marrow Graft by the Irradiated Mouse. J. W. Hollingsworth. Yale J. Biol. & Med. **31**: 157–163, December 1958. (VA Hospital, West Haven, Conn.)

Heavily irradiated mice have been protected from otherwise lethal bone marrow damage by intravenous

injection of rat bone marrow. However, rat bone marrow is the only "heterologous" marrow that has been found acceptable to the irradiated mouse. The studies reported in this article deal with the compatibility factors between rat and mouse that allow this interspecies marrow-graft acceptance.

Male and female mice of inbred strains (C57 Black × 101 or C_3H × 101 hybrids), ten to fourteen weeks of age, were irradiated at 200 kv for a dose of 700 r, which is at least 200 r beyond the 100 per cent lethal point in the author's system of irradiation. The usual marrow inoculum consisted of approximately 5 to 7 million nucleated cells.

In studies involving the destruction of red blood cells the erythrocytes to be tested were labeled with radioactive sodium chromate and injected into mice only a few minutes after irradiation. Determinations of blood radioactivity in the recipients were made by collecting the blood after decapitation and counting the sample thus obtained in a well-type scintillation counter. Counts from the blood of 2 to 6 mice were averaged and expressed as per cent of dose injected, assuming a total blood volume of 2.0 ml.

Labeled rat erythrocytes given to normal mice persisted in the circulation for about three days and then rapidly and completely disappeared. The disappearance was associated with the appearance of anti-rat erythrocyte agglutinins of variable titer in normal mice. When labeled rat erythrocytes were injected into irradiated, isologous-marrow-treated mice, the lifespan of cells was not markedly decreased, and no demonstrable anti-rat erythrocyte agglutinins appeared in the serum. Indeed, the disappearance rate of labeled rat erythrocytes in the irradiated mouse was similar to the curve of disappearance of chromium-51 tagged isologous and homologous mouse erythrocytes and autogenous rat erythrocytes.

Other rodent erythrocytes are basically incompatible in the mouse and are rapidly destroyed even by the irradiated mouse recipient.

The similarity of antigenic structure of rat and mouse erythrocytes is manifested by marked cross-reactivity of antisera produced in the rabbit. However, rat erythrocytes regularly produced an immune response in mice.

These observations suggest that, because of the marked antigenic similarities of the mouse and rat erythrocytes, immune tolerance to rat marrow might occur. This would be a more attractive hypothesis, however, if the rat erythrocyte did not also possess good antigenicity in the mouse. The alternative explanation that the prolonged acceptance of rat marrow is related to total replacement of mouse immune tissues by rat donor immune tissues remains a possibility.

Three graphs; 1 table.

Modification of X-Radiation Lethality by Autologous Marrow Infusion in Dogs. Edward L. Alpen and S. J. Baum. Blood **13:** 1168–1175, December 1958. (U. S. Naval Radiological Defense Laboratory, San Francisco, Calif.)

A comparison of the protection afforded by the use of autologous and homologous bone marrow injections in dogs irradiated with 400 r and 600 r is presented.

Animals were divided into four groups: autologous marrow treated, homologous marrow treated, saline injected, and control. The x-ray machine was operated at 250 kvp, 15 ma, with a target-to-midline distance of 115 cm. Filtration of 0.5 mm. of copper and 1.0 mm. of aluminum was used. The initial h.v.l. was 1.8 mm. in copper. The dose rate measured in air at the potential midline was 11.0 r/minute. While still anesthetized, the dogs were injected according to group. The technic was the same for both experiments.

In neither of the experiments was protection afforded by homologous and saline injections. With autologous injections protection was demonstrated to levels as high as twice the LD 50. Dogs receiving 2×10^9 autologous nucleated cells were protected against both 400 r and 600 r. Dogs given 1×10^9 autologous nucleated cells failed to survive 600 r.

The failure of homologous nucleated cells to protect dogs, in contrast to its effect in monkeys and mice, is explained as a livelier rejection of foreign cells by dogs as part of an immune response.

It is submitted that a functioning hematopoietic potential after irradiation injury is adequate for survival.

Six graphs; 3 tables. W. J. VARLEY, M.D.
Mercy Hospital, Pittsburgh, Penna.

Growth of Primate and Nonprimate Tissue Culture Cell Lines in X-Irradiated and Cortisone-Treated Rats. Lewis L. Coriell, Robert M. McAllister, Bernard M. Wagner, Sheldon R. Wilson, and Selena A. Dwight. Cancer **11:** 1236–1241, November-December 1958.

In their efforts to establish normal human cell lines in tissue culture, the authors found that, if serial culture passages are sufficiently prolonged, the cells become altered. These cells then do not differ essentially from cancer cells, and can invade tissue and produce death in suitably prepared hosts (x-irradiated, cortisone-treated rats). The cells undergo alteration progressively with continuation of the culture and the passage of time.

Over 1,300 rats were studied. Each received 250 r total-body irradiation followed by repeated intramuscular injections of cortisone and intraperitoneal injections of tissue culture cells. When the cells were from lines which had been continuously propagated for at least three and a half years, they consistently produced large, solid, intraperitoneal tumors.

The explanation of the alterations is as yet unknown, but the answers may prove important in the understanding of cancer. The observations in this study appear to support and verify previous work with transplanted mouse tumors. The final implication is that there is no essential difference, except perhaps in degree, between the altered normal cells and cancer cells. "Some optimism," say the authors, "may be permissible in expecting increased precision and speed of research through the application of combined tissue culture techniques and animal experiments to a study of the mechanisms of cancer."

Three photomicrographs; 1 table.

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Quantitative Relation of RBE in Tradescantia and Average LET of Gamma-Rays, X-Rays, and 1.3-, 2.5-, and 14.1-Mev Fast Neutrons. Alan D. Conger, M. L. Randolph, C. W. Sheppard, and Helen J. Luippold. Radiation Res. **9:** 525–547, November 1958. (University of Florida, Gainesville, Fla.)

The authors investigated the effectiveness of x-rays and monoenergetic 2.5-Mev D, D and 14.1-Mev D, T

fast neutrons in one experiment, of x-rays and Co^{60} gamma rays in another, and of cyclotron neutrons in a previous experiment. The production of chromosomal aberrations was analyzed in the flowering plant, *Tradescantia*. A conservative estimate of the overall accuracy in these experiments is 15 per cent for physical values, 20 per cent for biological values, and 20 per cent for average linear energy transfer (LET, rate of energy loss, kev/μ) values as defined; it is believed that actually the overall accuracy for all three factors is considerably better than this.

Track average and energy average LET's are derived for each radiation in order to make comparisons of RBE (relative biological efficiency) against LET. The assignment of proper LET values and subsequent comparisons are relatively simple and straightforward when the ionization generated in tissue is substantially homogeneous. When tissue ionization is not homogeneous, but is made up of components of quite different average LET, the comparison is more complex because each separate component contributes a different relative amount to total dose, total track length, and total biological effect. For these cases, the biological and physical role of each component should be considered separately.

RBE was compared against average LET for the radiations used, and to higher LET of α-particles and heavy particles from the D, T neutron irradiation. RBE increases smoothly and about sevenfold from γ-rays to 1-Mev average-energy cyclotron neutrons (track average LET range from 0.27 to 27 kev/μ), peaks somewhere between 1-Mev fast neutrons and α-particles in the average LET range of 50 to 70 kev/μ at an RBE of 8 to 11, and then falls toward the higher-LET α-particles and D, T heavy particles. Within the fast-neutron energy range, from 14-MEV D, T to 1-Mev cyclotron to 2.5-Mev D, D neutrons (track average LET of 12, 27, and 31 kev/μ), RBE increases threefold. The shape of the curve of RBE against LET for chromosomal aberrations, an effect that may be considered as cellular cytogenetic lethality, is very similar to the curve for a galaxy of mammalian effects including lethality. In absolute amount, chromosomal RBE's are greater than those for mammalian lethality.

One figure; 5 tables.

Relative Biological Effect of 14-Mev Neutrons with the Broad Bean Root (Vicia faba) as a Test System. J. F. Spalding, S. B. Hawkins, and J. A. Sayeg. Radiation Res. **9**: 548–551, November 1958. (Los Alamos Scientific Laboratory, Los Alamos, N. Mex.)

In earlier articles (see, *e.g.*, Radiation Res. **8**: 322, 1958), the relative biological effectiveness (RBE) of β- and α-particles as tested with the broad bean root was reported. The present study was carried out to determine the RBE of 14-Mev neutrons employing the same test system.

The LD 50 dose of 14-Mev neutrons was 125.9 $\pm$ 9.6, and the LD 50 dose of γ-rays from Co^{60} was 401.4 $\pm$ 21.2.

When the γ-ray LD 50 was used as a base line, the RBE for 14-Mev neutrons was found to be 3.18 $\pm$ 0.32.

One table.

Wear and Tear on the Spine. A Contribution to the Reduction of Radiation to the Patient. K. Hohl. Radiol. clin. **27**: 365–372, November 1958. (In German) (Zentral Röntgen-Institut des Kant. Spitals St. Gallen, Switzerland)

The commonly observed signs of degeneration in the cervical spine, with diminishing mobility, increase with the age of the patient and are no indication of disease. For the detection of clinically significant abnormality, the author advocates functional radiography, whereby the spine is examined in the neutral position, in marked flexion, and in extension. In such a study decreased mobility between two vertebral bodies can be detected and abnormal vertebral displacement resulting from injury to the disk can be recognized. This latter condition may be completely non-detectable in the neutral lateral view.

The author was able to reduce the x-ray dosage in such studies to about a twentieth by the use of high voltage (90 to 120 kv), total filtration of 4 mm. Al, focus-film distance of 3 meters, and Kodak Royal Blue film.

Twelve roentgenograms; 1 chart; 2 tables.

CHRISTIAN V. CIMMINO, M.D.
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Radiation Dose Reduction in Dental Roentgenography. Lewis E. Etter, S. S. Sidhu, and L. C. Cross. Am. J. Roentgenol. **80**: 926–932, December 1958. (L. E. E., Falk Clinic, University of Pittsburgh, Pittsburgh 13, Penna.)

One of the chief sources of imperfectly controlled radiation is to be found in dental roentgenography. Dental machines are operated at relatively low kilovoltages and current values, for long exposures, with no diaphragming of the beam or filtration, at short focal-film distances, and often with relatively slow film. Utilizing such machines, the authors investigated roentgen exposures to the neck, thyroid, skin of the abdomen, and gonads, with "conventional" dental filming technics. It was found that full-mouth radiography may administer as much as 35 r to each side of the neck and over the thyroid, doses in the range of 33 mr to the skin of the abdomen, and one-third to two-thirds of this amount to the gonads. The simple addition of 2 mm. Al filter and use of slightly higher kilovoltage with fast films will reduce the head and neck exposures by a factor of about seven. The doses to the skin of the abdomen and gonads, however, are only mildly decreased. Newer dental radiography machines utilizing 90- to 100-kv technics with 16-inch target-film distances and fast film can cut the exposures to the head and neck by a factor of 100 compared to the conventional low-quality beams, and will reduce exposure to the gonadal areas by approximately similar magnitudes.

The authors used a specially constructed manikin for measurement of the roentgen dosages. Results are presented in table and graph form. Radiographs of teeth obtained with various technics are shown. It is evident that the high-kilovoltage, high-quality, fast film technics yield better results.

Four roentgenograms; 4 graphs; 3 tables.

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